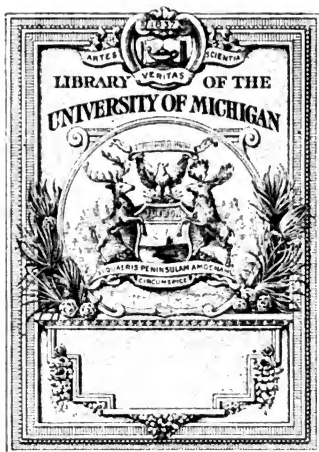




The School of Mines quarterly

Columbia University. School of Chemistry



IN
537

THE
SCHOOL OF MINES
QUARTERLY,

A
JOURNAL OF APPLIED SCIENCE.

VOL. XII.

NOVEMBER, 1890, TO JULY, 1891.

COLUMBIA COLLEGE,
NEW YORK CITY.

1891.

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VOL. XII.

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THE SCHOOL OF MINES QUARTERLY.

VOL. XII.

NOVEMBER, 1890.

No. 1.

THEORY OF STRESS IN A GRANULAR MASS.

BY T. C. COYKENDALL.

In this Thesis it is proposed to discuss the following subjects :

1°. To find the ratio of the conjugate stresses in a granular mass when the mass is in equilibrium.

2°. To transform the expression for the ratio of conjugate stresses, so that logarithms may be conveniently applied.

3°. To find the ratio of the thickness of a retaining wall, to the height of the same when the slope, angle of repose, weight per cubic foot of earth sustained, and weight per cubic foot of the material of the wall are given.

4°. To give and demonstrate the truth of a graphical method by which the thickness of a retaining wall may be found when the height, slope, angle of repose, weight per cubic foot of earth sustained, and weight per cubic foot of the material of the wall are given.

In the discussions which follow, the notation here given will be used :

θ = The slope of the surface of the granular mass.

ϕ = The angle of repose of the material of the granular mass.

As an introduction to the discussion of the principles which follow, a general discussion of stress in a granular mass will be given.

If we conceive a granular mass to be divided by any plane,

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the stresses which occur between the two portions into which the plane divides the mass are the forces which tend to destroy the equilibrium of the mass. It is a well-known principle of mechanics that if two surfaces are in contact, no movement of one, with reference to the other, can take place, unless the resultant of all applied forces to one of the two surfaces makes, with the normal to that surface, an angle greater than the angle of friction between the two surfaces. In a granular mass the surfaces along any plane of division may be considered as plane surfaces in contact. Therefore we have as the condition of stability of a granular mass the following principle. In the statement of this principle and hereafter in this discussion, the angle between the normal to any surface and the resultant of all applied forces to that surface, will be referred to as the obliquity.

A granular mass is in equilibrium when the maximum obliquity of stress upon any plane of division of that mass is equal to or less than the angle of repose of the material of that granular mass.

When a granular mass is acted upon by a system of parallel forces, as the attraction of the earth for each of the particles of the mass, two additional systems of stress are developed. It has been shown by Rankine that if a granular mass be acted upon by a system of vertical forces, a system of forces is developed parallel to the surface of the mass. It is therefore evident, from the laws of force, that an additional system of forces must be developed perpendicular to the surface of the mass.

The following theorem has also been demonstrated, by Rankine:*

"If the stress on a given plane in a body be in a given direction, the stress on any parallel plane to the direction of stress on the first plane will be parallel to the first plane." In the demonstration of the principles of conjugate stresses which follows, it has been found unnecessary to refer the stresses to the axes of principal stress for the purposes of the demonstration, and a much simpler, and at the same time an absolutely rigorous method of demonstration has been used. In that which follows the only stresses considered are those which tend to destroy the equilibrium of the granular mass.

The method of procedure is as follows:

1°. The general equation for the obliquity of stress on any plane is obtained.

* *Art. 101, App. Mech.,*

2°. The relation which must exist between the variables of this equation, when the obliquity is maximum, is found.

3°. This expression for maximum obliquity is placed $= \varphi$. In accordance with the preceding principles, it is proposed to demonstrate the following theorem :

THEOREM.

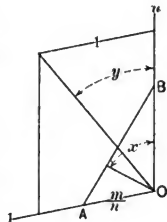
The ratio of the conjugate stresses in a granular mass is equal to

$$\frac{\cos \theta + \sqrt{\cos^2 \theta - \cos^2 \varphi}}{\cos \theta - \sqrt{\cos^2 \theta - \cos^2 \varphi}}$$

Let n represent the ratio of the conjugate stresses : then as the absolute values of the stresses do not enter into the discussion, we may consider that the vertical stress is represented by n while the inclined stress is represented by unity. Let AB represent any plane. Let the distance $BO = 1 \therefore$ The stress upon $BO = 1$.

Let the stress upon $AO = m \therefore AO = \frac{m}{n}$.
Let y = the angle between the resultant of these stresses and the line OC .

Let x = the angle which the normal to the plane AB makes with the line OC .
Then from trigonometrical principles we have



$$\frac{\cos y}{-\cos (\theta - y)} = \frac{1}{m}$$

$$\therefore \tan y = \frac{-\cos \theta}{m + \sin \theta}$$

Similarly,

$$\frac{\cos x}{\sin (x - \theta)} = -\frac{\cos \theta}{m + \sin \theta}$$

$$\therefore \tan x = \frac{n + m \sin \theta}{m \cos \theta}$$

$$\text{Obliquity} = O = (x - y)$$

$$\begin{aligned} \therefore \tan O &= \frac{\frac{n + m \sin \theta}{m \cos \theta} + \frac{\cos \theta}{m + \sin \theta}}{1 - \frac{\cos \theta (n + m \sin \theta)}{m \cos \theta (m + \sin \theta)}} \\ &= \frac{m^2 \sin \theta + m (n + 1) + n \sin \theta}{m^2 \cos \theta - n \cos \theta} \end{aligned}$$

It is required to find the relation which must exist between m and the other quantities of the left member in order that $\tan O$ shall be a maximum.

In accordance with the usual rules for maxima and minima values we proceed as follows:

$$\frac{d(\tan O)}{d m} = \frac{(m \cos \theta - n \cos \theta) (2 m \sin \theta + n + 1) - [m^2 \sin \theta + m (n + 1) + n \sin \theta] 2 m \cos \theta}{(m^2 \cos \theta - n \cos \theta)^2}$$

$$\therefore (m \cos \theta - n \cos \theta) (2 m \sin \theta + n + 1) - [m^2 \sin \theta + m (n + 1) + n \sin \theta] 2 m \cos \theta = 0$$

Performing the indicated operations and reducing, we have,

$$m^2 (n + 1) + 4 m n \sin \theta = -n (n + 1)$$

$$\therefore m^2 + \frac{4 m n \sin \theta}{n + 1} = -n$$

Solving for m we have,

$$m = \frac{-2 n \sin \theta \pm \sqrt{-n (1 + n)^2 + 4 n^2 (1 - \cos^2 \theta)}}{n + 1}$$

But in this expression we have used the reaction due to the inclined force and not that force itself and since the reaction is in the opposite direction, it is negative.

\therefore We must substitute for n , $-n$, if we represent the ratio of the vertical force to the inclined force.

$$\therefore m = \frac{2 n \sin \theta \pm \sqrt{n (n + 1)^2 - 4 n^2 \cos^2 \theta}}{1 - n}$$

Also,

$$\tan O = \frac{m^2 \sin \theta + m(1-n) - n \sin \theta}{m^2 \cos \theta + n \cos \theta}$$

Substituting the preceding value for m in the expression for $\tan o$ we have

$$\begin{aligned} \tan O &= \frac{2n \sin \theta [2n \sin^2 \theta + (1-n)^2] - n(1-n)^2 \sin \theta + [(1+n)^2 \pm \sin \theta \sqrt{n(n+1)^2 - 4n^2 \cos^2 \theta} - 4n \cos^2 \theta] \sqrt{n(n+1)^2 - 4n^2 \cos^2 \theta}}{4n^2 \sin^2 \theta \cos \theta \pm 4n \sin \theta \cos \theta \sqrt{n(n+1)^2 - 4n^2 \cos^2 \theta} + \cos \theta [n(n+1)^2 - 4n^2 \cos^2 \theta] + n \cos \theta (1-n)^2} \\ &= \frac{[(n+1)^2 \pm 2 \sin \theta \sqrt{n(n+1)^2 - 4n^2 \cos^2 \theta} - 4n \cos^2 \theta] \sqrt{n(n+1)^2 - 4n^2 \cos^2 \theta}}{[(n+1)^2 \pm 2 \sin \theta \sqrt{n(n+1)^2 - 4n^2 \cos^2 \theta} - 4n \cos^2 \theta] 2n \cos \theta} \\ &= \frac{\sqrt{(n+1)^2 - 4n \cos^2 \theta}}{2 \cos \theta \sqrt{n}} \end{aligned}$$

Let φ = the maximum obliquity.

$$\therefore \tan \varphi = \frac{\sqrt{(n+1)^2 - 4n \cos^2 \theta}}{2 \cos \theta \sqrt{n}}$$

Squaring and adding one to both sides we have

$$\begin{aligned} 4n \cos^2 \theta &= \cos^2 \varphi (n+1)^2 \\ \therefore \frac{n^2 + 2n(\cos^2 \varphi - 2 \cos^2 \theta)}{\cos^2 \varphi} &= -1 \end{aligned}$$

Solving for n

$$\begin{aligned} \therefore n &= \frac{-\cos^2 \varphi + 2 \cos^2 \theta \pm 2 \cos \theta \sqrt{\cos^2 \theta - \cos^2 \varphi}}{\cos^2 \varphi} \\ &= \frac{-\cos^2 \theta + 2 \cos^2 \theta \pm 2 \cos \theta \sqrt{\cos^2 \theta - \cos^2 \varphi}}{\cos^2 \theta - (\cos^2 \theta - \cos^2 \varphi)} \\ \therefore n &= \frac{\cos \theta + \sqrt{\cos^2 \theta - \cos^2 \varphi}}{\cos \theta - \sqrt{\cos^2 \theta - \cos^2 \varphi}} \end{aligned}$$

Q. E. D.

THEOREM.

The intensity of the resultant of all forces applied to a vertical plane of a granular mass per unit of area of that plane, when the slope is negative and the mass is in equilibrium, is expressed by the formula :

$$R = P \frac{\cos \theta - \sqrt{\cos^2 \theta - \cos^2 \varphi}}{\cos \theta + \sqrt{\cos^2 \theta - \cos^2 \varphi}} \sqrt{1 + \tan^2 \theta \left\{ \frac{1 + \sin \varphi}{1 - \sin \varphi} \right\}^2}$$

When the slope is negative it is evident that there is a component of the stress which acts in a direction perpendicular to the direction of the slope. Then the stress on any vertical plane is the resultant of this component and of the component which acts parallel to the slope of the mass.

Let P_s = intensity of component parallel to slope, in direction of any plane perpendicular to this stress, per unit of area of that plane. Let P_n = intensity of perpendicular component per unit of area of a plane perpendicular to the direction of the stress. Let P_1 = the intensity of the component parallel to the slope, per unit of area of the plane to which it is conjugate. Let P = the intensity of the vertical component, per unit of area of the plane to which it is conjugate.

Then the stress upon any vertical plane will be the resultant of these two stresses upon that plane. The stresses P_1 and P_2 may be considered conjugate.

$$\therefore P_2 = P_s \frac{1 + \sin \varphi}{1 - \sin \varphi}$$

$$\text{But } P_s = \frac{P}{\cos \theta} \left\{ \frac{\cos \theta - \sqrt{\cos^2 \theta - \cos^2 \varphi}}{\cos \theta + \sqrt{\cos^2 \theta - \cos^2 \varphi}} \right\}$$

$$\therefore P_2 = \frac{P}{\cos \theta} \left\{ \frac{1 + \sin \varphi}{1 - \sin \varphi} \right\} \left\{ \frac{\cos \theta - \sqrt{\cos^2 \theta - \cos^2 \varphi}}{\cos \theta + \sqrt{\cos^2 \theta - \cos^2 \varphi}} \right\}$$

The intensity of P_2 per unit of area of a vertical plane = $F_2 \sin \theta$.

$$\therefore R = \sqrt{P_1^2 + P_2^2 \sin^2 \theta}$$

$$\therefore R = P \frac{\cos \theta - \sqrt{\cos^2 \theta - \cos^2 \varphi}}{\cos \theta + \sqrt{\cos^2 \theta - \cos^2 \varphi}} \sqrt{1 + \tan^2 \theta \left\{ \frac{1 + \sin \varphi}{1 - \sin \varphi} \right\}^2}$$

Let \mathcal{A} = the angle which this resultant makes with the slope.

$$\therefore \tan \mathcal{A} = \tan \theta \left\{ \frac{1 + \sin \varphi}{1 - \sin \varphi} \right\}^2$$

2°. It is required to transform the preceding expressions so that logarithms may be conveniently applied.

$$\frac{1}{n} = \frac{\cos \theta - \sqrt{\cos^2 \theta - \cos^2 \varphi}}{\cos \theta + \sqrt{\cos^2 \theta - \cos^2 \varphi}}$$

$$\begin{aligned} \sqrt{\cos^2 \theta - \cos^2 \varphi} &= \sqrt{(\cos \theta + \cos \varphi) \times (\cos \theta - \cos \varphi)} \\ &= 2 \sqrt{\cos \frac{1}{2} (\varphi + \theta) \cos \frac{1}{2} (\varphi - \theta) \sin \frac{1}{2} (\varphi + \theta) \sin \frac{1}{2} (\varphi - \theta)} \\ &= 2 \sqrt{\sin \frac{1}{2} (\varphi + \theta) \cos \frac{1}{2} (\varphi + \theta) \sin \frac{1}{2} (\varphi - \theta) \cos \frac{1}{2} (\varphi - \theta)} \\ &= 2 \sqrt{\sin (\varphi + \theta) \sin (\varphi - \theta)} \end{aligned}$$

$$\text{Let } 2 \sqrt{\sin (\varphi + \theta) \sin (\varphi - \theta)} = \cos N$$

$$\begin{aligned} \therefore \frac{1}{n} &= \frac{\cos \theta - \cos N}{\cos \theta + \cos N} \\ &= \frac{\sin \frac{1}{2} (N + \theta) \sin \frac{1}{2} (N - \theta)}{\cos \frac{1}{2} (N + \theta) \cos \frac{1}{2} (N - \theta)} \end{aligned}$$

$$= \tan \frac{1}{2} (N + \theta) \tan \frac{1}{2} (N - \theta)$$

$$\therefore \log \left(\frac{1}{n} \right) = \log \tan \frac{1}{2} (N + \theta) + \log \tan \frac{1}{2} (N - \theta)$$

To this formula logarithms may be conveniently applied.

We have now to transform the expression,

$$R = P \frac{\cos \theta - \sqrt{\cos^2 \theta - \cos^2 \varphi}}{\cos \theta + \sqrt{\cos^2 \theta - \cos^2 \varphi}} \sqrt{1 + \tan^2 \theta \left\{ \frac{1 + \sin \varphi}{1 - \sin \varphi} \right\}^2}$$

so that logarithms may be conveniently applied.

When $\theta = 0$, let $N_0 =$ the resulting value of n .

$$n = \frac{1 + \sin \varphi}{1 - \sin \varphi} = \tan \frac{1}{2} N_0$$

N_0 denoting the value of N when $\theta = 0$.

$$\therefore R = P \tan \frac{1}{2} (N + \theta) \tan \frac{1}{2} (N - \theta) \sqrt{1 + \tan^2 \theta \tan^2 \frac{1}{2} N_0}$$

Let $\tan \theta \tan \frac{1}{2} N_0 = \tan M$.

$$\therefore R = P \tan \frac{1}{2} (N + \theta) \tan \frac{1}{2} (N - \theta) \sec M$$

$$\therefore \text{Log } R = \text{log } P + \text{log } \tan \frac{1}{2} (N + \theta) + \text{log } \tan \frac{1}{2} (N - \theta) + \text{log } \sec M$$

To this expression logarithms may be conveniently applied.

3°. to find the ratio of the thickness of a retaining wall to the height of the same.

Let $P =$ total pressure applied at back of wall.

$$\therefore P = \frac{W h^2 \cos \theta}{2 n}$$

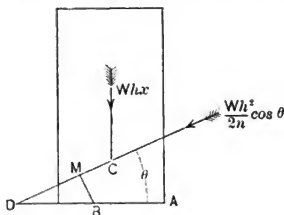
The moment of this pressure with respect to the outer edge of the middle third of the base will now be found. In that which follows:

$W =$ weight per cubic foot of earth sustained.

$W =$ weight per cubic foot of wall.

$h =$ height of wall.

$x =$ thickness of wall.



$$AP = \frac{1}{3} \frac{h}{\tan \theta}$$

$$BP = \frac{h}{3 \tan \theta} - \frac{2}{3} x$$

$$= \frac{1}{3} \left\{ \frac{h}{\tan \theta} - 2x \right\}$$

$$\therefore B M = \frac{1}{3} \left\{ \frac{h}{\tan \theta} - 2x \right\} \sin \theta$$

\therefore The moment of P with respect to the middle third of the base is

$$\begin{aligned} = B M \times F &= \frac{W' h^2}{6} \left\{ \frac{h}{\tan \theta} - 2x \right\} \frac{\cos \theta \sin \theta}{n} \\ &= \frac{W' h^3}{6n} \left\{ h \cos^2 \theta - 2x \cos \theta \sin \theta \right\} \end{aligned}$$

Moment of weight of wall, which acts through the center of gravity, with respect to the outer edge of middle third

$$= \frac{W x^2 h}{6}$$

If the wall is stable these two moments must be equal

$$\begin{aligned} \frac{W x^2 h}{6} &= \frac{W' h^3}{6n} \left\{ h \cos^2 \theta - 2x \cos \theta \sin \theta \right\} \\ \frac{x^2}{h^2} &= \frac{W'}{Wn} \left\{ \cos^2 \theta - 2 \frac{x}{h} \sin \theta \cos \theta \right\} \\ \frac{x^2}{h^2} + 2 \frac{W'}{Wn} \sin \theta \cos \theta \frac{x}{h} &= \frac{W'}{Wn} \cos^2 \theta \end{aligned}$$

Solving for $\frac{x}{h}$ we have

$$\frac{x}{h} = \cos \theta \left\{ \sqrt{\frac{W'}{Wn} + \frac{W'^2}{W^2 n^2} \sin^2 \theta} - \frac{W'}{Wn} \sin \theta \right\}$$

which is the required formula for the ratio of the height to the thickness.

4°. To give and demonstrate the truth of a graphical method

Take $ON = OM$.

Draw SN .

Take $FN = SN$.

Draw $FJ \perp$ to IJ , then it will intersect IJ in some point as J .

Take $OE = OJ$.

Draw SE and SB .

According to any scale lay off the height of the wall OC . Draw CR parallel to BS then will it intersect OS in some point as R . Draw RD parallel to SE then it will intersect EB in some point as D . Then is OD the thickness of the required wall according to the scale which was used in laying off OC .

For according to the construction

$$\frac{OH}{OT} = \frac{OK}{OA} \quad \therefore \frac{OK}{OB} = \frac{W'}{W_n} \quad \therefore \frac{OP}{OB} = \frac{W'}{W_n}$$

$$\therefore \text{According to the construction} \quad \frac{OS}{OB} = \sqrt{\frac{W'}{W_n}}$$

Also since $IOB = \theta$ and KM is \perp to IO we have

$$\frac{OM}{OB} = \frac{W'}{W_n} \sin \theta \quad \therefore \frac{ON}{OB} = \frac{W'}{W_n} \sin \theta$$

$$\frac{SN}{OB} = \frac{\sqrt{OS^2 + ON^2}}{OB} \quad \therefore \frac{SN}{OB} = \sqrt{\frac{W'}{W_n} + \frac{W'^2}{W_n^2} \sin^2 \theta}$$

$$\therefore \frac{OF}{OB} = \left\{ \sqrt{\frac{W'}{W_n} + \frac{W'^2}{W_n^2} \sin^2 \theta} - \frac{W'}{W_n} \sin \theta \right\}$$

$$\therefore \frac{OJ}{OB} = \cos \theta \left\{ \sqrt{\frac{W'}{W_n} + \frac{W'^2}{W_n^2} \sin^2 \theta} - \frac{W'}{W_n} \sin \theta \right\}$$

$$\therefore \frac{OE}{OB} = \cos \theta \left\{ \sqrt{\frac{W'}{W_n} + \frac{W'^2}{W_n^2} \sin^2 \theta} - \frac{W'}{W_n} \sin \theta \right\}$$

But it has already been shown that the right member of this equation = $\frac{x}{h}$.

may be deduced in a similar manner to the formula of the third discussion of this thesis, and a graphical construction may be made which is entirely analogous to that of the present discussion.

OUTBURSTS OF GAS IN METALLIFEROUS MINES.*

By BENNETT H. BROUGH, A.R.S.M., F.G.S., F.I.C.

THE recently published volume of the Reports of the Inspectors of Mines to Her Majesty's Secretary of State, contains an account of a lamentable accident, caused by a fire-damp explosion at the Mill Close lead mine, at Darley, in Derbyshire, on November 3, 1887. This mine, which is the largest and most productive in Derbyshire, is one of the oldest in the district, the records of the quantity of ore raised going back as far as the year 1684. The vein is frequently many yards in width, and traverses hard limestone overlain by shale. Ore is also found extending into many of the beds of shale. Fire-damp has occasionally been found in this mine, but only in small quantities. In 1886, however, two explosions occurred, by which two men were burned. Since that date, the quantity of gas emitted from the shale largely increased, and led to the use of locked safety-lamps. The account of the recent explosion given by Mr. Stokes,† Her Majesty's Inspector of Mines, is substantially as follows: On the morning of the accident, six miners went to work at a part of the mine called the forefield. They descended at midnight on November 2d. Upon their arrival at their working-place, the men tested for and found gas in and about the ends of the forefield. They thought, however, that the use of safety-lamps protected them from all danger.

* ROYAL SCHOOL OF MINES,
SOUTH KENSINGTON, S.W., April 17, 1890.

A. J. MOSES, ESQ., Manager of the "SCHOOL OF MINES QUARTERLY."

Dear Sir: In reference to your favor of the 4th inst, I feel much flattered by your proposal to print portions of my paper on "Gas Outburst" in your journal, and trust that your doing so will lead to further cases in American mines being recorded.

Yours faithfully,

BENNETT H. BROUGH.

† *Reports of the Inspectors of Mines*, for the year 1887, p. 377. London, 1888.

A shot was fired during the early part of the shift, and at 3 A.M. three shot holes were bored, within three or four feet of where the gas was known to have accumulated. These holes were charged with dynamite, and ignited by touch-paper, and a fuse carried down from the upper to the lower workings. After lighting the fuse, the men retired to what they thought was a place of safety about fifty yards away in the lower level or wagon-way. At this point they were joined by the two wagoners, and all awaited the firing of the shots. Suddenly an explosion occurred, and immediately five of the six men were buried and killed by a large fall of timber and stone. The sixth man escaped with burns and serious bruises. This man stated at the inquest that the explosion took place immediately after he heard the first shot go off, and from his evidence there can be little doubt that the first dynamite-shot fired the gas.

The Yoredale shale, whenever it occurs in beds of twenty-five to thirty-five fathoms in thickness, always gives off a little gas. Probably this gas had collected in the fissured limestone, and becoming ignited by the shot, forced down the rock masses upon the unfortunate miners.

This illustration of the disastrous effects of a fire-damp explosion in a metalliferous mine clearly proves that fire-damp, unfortunately, is not confined to collieries. In a number of cases it has been met with in mines of lignite, salt, diamonds, and metalliferous minerals. It has, therefore, been thought that it would be of interest to collect the records of cases in which outbursts of gas have been observed in metalliferous mines, with a view to arriving at an explanation of the phenomena.

* * *

Similarly, the fire-damp explosions that have occurred in salt mines are due to the presence of hydrocarbons produced by the decomposition of vegetable substances. The gray or blue color, so frequently met with in rock-salt, is due to the presence of bitumen. * * * * According to J. N. Bremer,* combustible gas was evolved in large quantities from a fissure in the marl in the rock-salt at the Szlatina mine, Marmaros county, Hungary, and was used for lighting the workings. At Gottesgabe, near Rheine, in Westphalia, the gas evolved was used in 1826 for lighting the workings,

* *Poggendorff's Annalen der Physik und Chemie*, vol. vii., 1826, p. 131.

and even conducted through wooden pipes to the manager's house, and there used for lighting and for cooking purposes. Similar outbursts of gas were utilized at Zugo, near Klein Saros, in Transylvania;* and at the Bex salt-mines in the canton of Vaud, Switzerland, fire-damp has, according to Brunet,† been used for lighting the workings, being received from the fissures in sheet-iron pipes. The gas, probably, comes from the inclosing limestones, which are possibly bituminous. It is a curious fact that the first fire-damp explosion recorded, is shown, by Professor F. Posepny,‡ to have occurred at a salt-mine at Hallstadt, in Austria, on September 9, 1664, twenty years before what is generally supposed to be the first historical evidence of the presence of fire-damp, given by Robert Plot,§ in 1684.

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In iron-mines, several explosions of fire-damp have been recorded. A. Daubrée|| met with fire-damp in the mines of pisolitic iron-ore at Gundershoffen and Winckel in Alsace. At Gundershoffen, the pisolitic iron-ore, which was worked up to 1825, occurs disseminated through a yellow clay overlying marls of Upper Liassic age. The ore-bed is covered by a grayish-blue clay, some twenty yards in thickness. In the bed, numerous nodules of gypsum are met with, and the clay immediately above the deposit is impregnated with grains of iron pyrites. In the bed, which was worked in 1818 at a depth of thirty-three yards, insignificant gas explosions were of frequent occurrence. In 1824, however, a serious explosion occurred, by which a number of miners were seriously injured. The Winckel bed is deposited in a hollow in white limestone of Upper Jurassic age. The pisolitic iron-ore is disseminated through a gray clay, and the whole is overlain by a limestone conglomerate. In 1832, an explosion occurred when some workings, that had been suspended for a time, were entered. Wooden planks were ejected from the shaft and thrown to a distance of ten yards from the mouth, and the only workman in the mine at the time was badly burned. An explosion of a less serious character oc-

* *Gilbert's Annalen der Physik*, vol. xxxvii., 1811, p. 1.

† *Comptes Rendus Mensuels de la Société de l'Industrie Minière*, 1882, p. 129.

‡ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xxxiii., 1885, p. 606.

§ *Natural History of Staffordshire*.

|| *Annales des Mines*, 4th Series, vol. xiv., 1848, p. 33.

curred on June 27, 1846. At the top of a level, a great influx of water was observed, and in raising his light to see whence it proceeded, the captain ignited the gas, and was thrown violently to the ground and slightly burned.

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In mines working true-fissure veins, numerous explosions have been recorded. In March, 1845, an explosion occurred in old workings that had not been entered for some years, at the now abandoned copper-mine of Grand-Saint-Jean, near Giromagny, in Alsace. Gas has been noticed on several occasions at Pontpéan, in Brittany, where it is still occasionally met with.* The vein consists of argentiferous galena and blende, and traverses, in a north and south direction, the ancient clay-slate. As there is a dislocation that has brought a portion of the deposit to the level of the Tertiary strata, it is possible that the gas outbursts are due to the influence of lignite deposits, which may exist in these beds.

Charlon† reports the occurrence of inflammable gas in the copper pyrites deposit of Rocca Federighi, in Tuscany. In 1875, a timbered level, that had been abandoned for two or three years, was encountered by a cross-cut. On holing, large quantities of water were ejected, and, immediately afterwards, an explosion occurred by which three workmen were seriously burned. Again, in 1877, at the same mine, an explosion occurred on opening an old adit level that had been abandoned for fifteen years. In this case a thin parting of rock separated the old level from that in which the men were working, and water, having an unpleasant odor, percolated through. A piece of the roof fell, and the captain, raising his lamp to see what was the extent of the disaster, exploded the gas, the three men in the level being seriously burned. From this description it appears that, under certain conditions, the decomposition of wood in water or in moist air may give rise to the formation of inflammable gas in exactly the same way as marsh-gas is produced in stagnant pools. The explosions that have occurred in some of the Saxon mines, when old workings were entered, may be explained in this way. The archives of the Royal Saxon

* *Rapport de M. Haton de la Goupillière au nom de la Commission d'Etude des Moyens Propres à Prévenir les Explosions du Grisou*, Paris, 1880, p. 39.

† *Comptes Rendus Mensuels de la Société de l'Industrie Minérale*, 1879, p. 6.

Mining Bureau, quoted by Tittel,* record several explosions of this kind.

At the St. Johannes Mine, at Rehhübel, in the Schwarzenberg district, a cross-cut was driven from the Urbanus adit level, at a distance of 760 feet from the mouth of the adit. On March 11, 1872, two miners were working at the end of this cross-cut, and at noon a quantity of water burst through. At 3.45 P.M. an explosion of gas occurred. One of the miners, though badly burned about the head, face and hands, found his way in the dark out of the adit and escaped. The dead body of the other miner was found at a distance of 643 feet from the mouth of the adit. It was subsequently found that the water from an old shaft accompanied by marsh-gas, which had in all probability been formed from the decaying timbers, had burst through an aperture and become ignited by the miners' lamps.

At the Churprinz Friedrich August mine, at Gross-schirma, in 1859, a brick dam was put in to keep out the surface-water. In 1882 the system of drainage was changed, and the dam was bored through in order to insert an iron pipe provided with a cock for letting off the water as required. While the boring was in progress, water and gas burst through, and an explosion followed by which the miners engaged were seriously injured. Similarly, at the Alte Hoffnung mine at Schönborn, a dam built in 1867 was opened in 1870, in order to ascertain whether there was as much water as formerly. The gas, issuing with the water, ignited, and the flame extended for twenty feet and burned for several seconds. Behind the dam, the level had been timbered for some thirty yards.

The presence of fire-damp in metalliferous mines cannot always be traced to the decomposition of timber under water. There was very little timber in the Winckel levels, and none at all in the Giromagny mine. In many mines, too, containing an enormous quantity of timber partially submerged, no trace of gas has been observed. This was the case at the Alter Deutscher Wilder Mann mine, near Grunl, in the Upper Harz. This mine was under water for 200 years, and was visited by the writer in 1882, immediately after the water had been pumped out.

Another explanation must be sought for the presence of fire-damp in the Monte Catini mine in Tuscany, where in 1845 many

* *Berg. und Hüttenmännische Zeitung*, 1882, p. 226.

miners lost their lives by an explosion, and in the celebrated Van mine near Llanidloes. The latter mine is the most productive lead-mine in the United Kingdom. The vein occurs in rocks of Lower Silurian age. The occurrence of gas at this time has been noted by Dr. C. Le Neve Foster.* Fire-damp was found at the adit, and in nearly every level below while tapping or making the first drivages on the lode. The gas rushes out with the water, making a great noise, and always appearing to come from below. The miners regard it as a sure harbinger of lead-ore. The quantity has sometimes been sufficient to cause slight explosions, by which miners have had their hair and beards singed. It is not improbable that sulphuretted hydrogen has also been emitted.

T. Macfarlane† describes the occurrence of fire-damp in the Silver Islet mine, situated on a small rocky island in Lake Superior. On December 28, 1875, while a party of miners were engaged in drilling a hole in the end of the drift at the 8th level, the drill suddenly broke into a crevice, from which water at once commenced to flow, but not in great quantity, and not being aware that it was accompanied by an emission of gas, one of the miners took a candle to look at the hole. The gas instantly took fire, sending out a flame of more than 40 feet in length. The hole was subsequently stopped with a wooden plug, and when a lighted candle was applied to the imperfectly plugged hole, the gas again ignited, giving a jet of flame about a foot in length, which continued to burn for several weeks.

In these cases, it appears probable that the gas has been derived from beds beneath the ore-vein, from which it has ascended through fissures into the workings.

Sulphuretted hydrogen has, in many places, been disengaged in sufficient quantity to become ignited. This occurred during the sinking of a well at Gajarine, near Conegliano, in Lombardy, and is described by L. E. F. Héricart de Thury.‡ The explosions described above cannot, however, be attributed to this cause, for if sufficient sulphuretted hydrogen had been present, it would at once have been detected by its characteristic odor, and by the odor of the sulphurous acid formed on its combustion.

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* *Transactions of the Royal Geological Society of Cornwall*, vol. x., 1879, p. 33.

† *Transactions of the American Institute of Mining Engineers*, vol. viii., 1880, p. 226.

‡ *Annales des Mines*, 3d series, vol. iv., 1833, p. 515.

In these cases the gas was probably produced from the decomposition of pyrites ores. This decomposition may be detected in many old mines. The writer has observed the presence of large quantities of sulphuretted hydrogen in abandoned workings at the Rammelsberg mine in the Harz, at the Falun mine in Sweden, and at several of the Hungarian mines. In other cases the acid waters produced by the oxidation of pyrites act on limestone and produce carbonic acid. Emanations of carbonic acid in the iron-ore mines of the Upper Erzgebirge are described by H. Müller.* Similar outbursts have been observed at the mines of Massa Maritima, in Tuscany, where a thick vein of pyrites and quartz traverses clay slate enclosing limestone beds. The hanging-wall of the vein is formed by a band of clay that conducts a quantity of water into the workings, and serves as a receptacle for gas, principally carbonic acid, probably produced in the manner indicated. A similar reaction may have produced the large quantities of carbonic acid given off from crevices in the south wall of the lode at the Foxdale lead mines in the Isle of Man. In 1883, when the writer visited these mines, the amount of gas given off at the eastern end of the 185 fathom level was so great that, notwithstanding the large volumes of compressed air continually forced in from two air pipes, candles would not burn, and the work was carried on under great difficulties.

In the same way carbonic acid was met with in 1875 in the Johannis Stehenden vein, in the Himmelsfürst mine, at Freiberg, in Saxony. Here, too, lights would not burn before a freshly opened cavity.

Carbonic acid, produced by the action of acid waters on limestone, is of not unfrequent occurrence in the Derbyshire lead mines. At a mine near Youghreave, the writer has seen this gas being raised in buckets attached to a windlass.

* * * * *

SUMMARY.

From the various records collected in this paper, it is believed that there is sufficient evidence to show that the gas-outbursts, that have been observed in metalliferous mines, are not all due to the same cause, and may be explained by the following hypotheses :

* *Gangstudien*, vol. iii., 1860, p. 302.

1. The decomposition of timber in a mine, in a similar manner to the decomposition of vegetable matter in marshes, may produce fire-damp which would accumulate in cavities that are ultimately broken into. This is evidently the explanation of the explosion in the Saxon mines, and in the Rocca Federighi mine.

2. In iron mines, where the iron is not entirely in the state of peroxide, water might be slowly decomposed, and hydrogen be produced. This, if the ventilation of the mine was defective, would accumulate in the upper portions of the underground excavations. This is a possible explanation of the explosions at Gundershoffen and Winckel.

3. In these cases, however, it is more probable that the gas was fire-damp, which emanated from beds beneath the ore-deposit and found its way, through fissures, into the workings. The gas would thus be produced in the same way as the natural gas of the United States, China and other countries, where it is given off from rocks of varied age inclosing bitumen. The Upper Liassic marls on which the Gundershoffen deposits rests, are often sufficiently bituminous to enable them to be burned. At Winckel, however, no such beds are met with below the deposit, though they occur in the Jurassic rocks of the vicinity. The same explanation is therefore feasible. At the Mill Close, and other mines in Derbyshire, the gas is derived from the Yoredale Shales, which are undoubtedly of a bituminous character. Bituminous matter has occasionally been found in mineral veins, and would appear to have been derived from the adjacent rock at the time of the filling of the vein fissure. In the Snailbeach lead-mine in Shropshire, small nests of bitumen abound in the vein, and the writer has found the same substance in geodes in some of the abandoned metalliferous mines of Alsace, near Mollau and St. Amarin, in the Vosges. The explosions at Monte Catini, Silver Islet, and the Van mines would appear to be due to natural gas derived from adjacent rocks.

4. Fire-damp may be produced from the decomposition of organic matter, in the same way as the hydrocarbons met with in salt mines. At Ponpéan, and at the Voulte mine, the fire-damp was apparently derived from beds of lignite in the vicinity.

5. Explosions have in some cases been caused by outbursts of sulphuretted hydrogen, produced by the action of acid waters on pyrites ore.

6. The outbursts of carbonic acid met with at Foxdale, Freiberg

and Massa Maritima, may have been caused by the action of acid waters, produced by the oxidation of pyrites, on limestones or metalliferous carbonates.

* * *

MR. JAMES WILLIS said it was a frequent occurrence to have slight explosions of gas in the hematite mines of Cleator and other places in Cumberland. Last year one man was killed by such an explosion in the Furness district. If the writer of this paper would go to the places, he might have an opportunity of examining these gases. The supposition of the writer was that the gases referred to in the paper arose from the decomposition of wood.

* * *

MR. WHITE said that when he had charge of the South Skelton iron-mine in Cleveland, there were two men very badly burned indeed. For some time they were so very much bothered with gas that Davy lamps had to be used in working some parts. In the Liverton mine, near to South Skelton, they had always, he believed, had some trouble with gas. For a considerable period there was an oily fluid to be seen trickling down the sides of the boards from the roof in the ironstone-mine. In his case the timber had nothing whatever to do with the matter.

* * *

MR. BELL said he thought it was from the jet shale that the gas came into the Cleveland mines. In one of them he had seen more gas than in a coal-mine. As to gases in metalliferous mines, he had seen some in two or three places traceable to some shales. In another instance, where a man was burned, there was a small coal seam, six or seven inches thick, where the gas had evidently come from, and exploded at his light. It was a common thing in all lead mining districts to have gas here and there from the shale, or small coal seams, or from both of them. In the place Mr. White spoke of he (Mr. Bell) had traced it as coming from the jet shale.

* * *

MR. J. M. LIDDELL said that in the diamond mines of South Africa there was a great amount of carboniferous shale, and in working amongst it there had happened one or two explosions. In one case a shaft was sunk through a small amount of shale, and in another a drift was driven into a large mass of shale, and explo-

sions occurred. He thought that as they got deeper they would have to take more care.

MR. WILLIS said that four or five years ago at the Fallowfield lead mine five men were burned by gas from an adjoining coalfield. There was a very large trouble in the coal-field which seemed to throw the lead-measures to about their level.

* * *

MR. BELL: The cases mentioned in this paper might be multiplied twenty-fold.

EXAMINATION OF MINES.

BY PROF. H. S. MUNROE.

(Continued from Vol. XI., p. 201.)

In a previous article* it was shown that questions as to the value of a mining property, and as to methods of working, cannot be answered definitely until the character and probable extent of the deposit are well determined. This in turn requires that the property be developed by surface and underground workings. To determine whether the property is worth development, and to devise a systematic and economical plan of exploration demand careful preliminary study. The method of making the necessary examination and surveys for this preliminary study was described at length in the above-mentioned paper.

Passing over for the present the methods of prospecting and of developing a mining property, the present paper will treat of the examination of mines or of developed mineral properties.

The objects of such examination are the valuation of the property and the determination of the proper method of working the deposit, including, among other things, the proper scale of mining operations.

VALUATION OF MINES.

The value of a mine is determined by its capacity for earning profits or dividends.

If, for example, we assume the proper rate of interest, all things

* Examination of Mineral Properties, SCHOOL OF MINES QUARTERLY, vol. xi., No. 3, p. 193.

considered, at 10 per cent., then a mine earning one hundred thousand dollars a year should be worth a million dollars.

The problem, however, is not as simple as it would appear at first sight, and the determination of the proper rate of interest demands careful consideration.

In the first place, the business of mining is peculiar, in that it is a temporary business. Any given mineral deposit or mining property will be exhausted sooner or later; and the more actively it is worked the sooner will the business of mining come to an end.*

The value of a mine should, therefore, be computed on the basis of the present value of a limited annuity, and not according to the rules of simple interest.

Again, the business of mining is risky. All mineral deposits are more or less uncertain. Even beds of coal, perhaps the most regular of all, are liable to contain unworkable areas, and often pinch out and disappear entirely. In the case of metalliferous deposits, irregularity and uncertainty are the rule rather than the exception. An engineer's estimate of the yield of a deposit, or the life of a mine, must take into account this element of uncertainty, which is greater for some classes of deposits than for others.

Mining is subject as well to the ordinary risks of similar business operations. The market value of the product varies with supply and demand, is affected by the cost of transportation, by tariff legislation, and by other outside influences. The cost of labor and of the necessary supplies is also subject to change, and the profits of mining may be seriously reduced thereby. The mine workings and surface plant are liable to be destroyed by fire and by floods, and by other accidents peculiar to mining, such as explosions of fire-damp and the caving-in of the overlying strata.

The fact that mining is a temporary business makes it necessary to provide for the repayment of the capital invested in the property, and that required for the development and working of the mine. In estimating the profits a certain sum must be added to the working expenses to provide a sinking fund for this purpose. This fund should be large enough to extinguish the capital within

* The rapid exhaustion of mines is a characteristic feature of modern mining, especially in this country. In the older mining regions of Europe are mines centuries old and still productive. In this country mines equally large and deep have been excavated in a single generation. The introduction of machine drills and high explosives have revolutionized the art of mining.

a less term of years than that estimated as the probable life of the mine.

In estimating the value of the mine, on the basis of an annuity for a term of years, the interest assumed in computing the present value of the annuity should be large enough to cover the mining risk.

For example, let us suppose the case of a mine with a total capital of one million dollars, which is to be repaid in ten years, money being worth 5 per cent. A sinking fund of about eighty thousand dollars per year will be required. To pay interest on the capital, with no allowance for mining risk, the mine must earn fifty thousand dollars additional, or one hundred and thirty thousand dollars in all. Thus the stock must earn 13 per cent. dividends per year in order to pay interest on the capital invested, and to repay that capital in ten years. In other words, the stock must earn over two and one-half times the commercial rate of interest to be worth par.

The same result is reached by the use of a table of annuities. Here we find that the present value of a ten-year annuity, money being worth 5 per cent., is 7.72 times the yearly income. With a present value of one million the income must be one hundred and thirty thousand dollars, as before.

In order to take into account the mining risk in the above case the yearly earnings under the above conditions should be not less than 20 per cent., and under some circumstances 30 or 40 per cent. per annum, or from four to eight times the commercial rate of interest.

In Nevada, when the Comstock mines were declaring large dividends the stocks yielded about 40 per cent. income per year on their selling price in the stock market. The commercial rate of interest in Nevada at that time was 10 per cent. The stock in this case earned four times the usual rate of interest, and was sold for two and a half times the yearly profits.

In the Lake Superior region the stocks of the dividend-paying mines earn from 8 to 25 per cent. per year on their average market value.

The Calumet and Hecla mine occupies an exceptional position in this respect. The mine earns from two to three millions in dividends per year, and is estimated to have at least thirty years' further life at the present enormous rate of production. The average selling price shows that the stockholders are content with 8 to 10 per

cent. interest. The allowance for mining risk in this case, assuming money to be worth 5 per cent., is very small.

Prof. J. C. Smock,* in estimating the value of the iron-mines of New Jersey, assumes the average life of the mines at fifteen years and the rate of interest at 4 per cent., and multiplies the yearly profits by seven to obtain the value of the mine. This corresponds to a yearly profit of 14 per cent., or three and a half times the rate of interest assumed.

Examples might be multiplied, but the above will serve to show that each case must be judged for itself. To estimate the value of any mine we must know the amount of capital required, the probable life of the mine and the yearly profits, and make due allowance for the mining risk.

When the deposit is completely exposed, or is of such a nature that its continuance may be safely predicted, the value of the property can be computed with great accuracy.

When, however, the deposit is unreliable, and its future cannot be predicted with any degree of certainty an accurate estimate of value is impossible.

In such case it is, perhaps, best to make two estimates of value. One of these should be based on the mineral† "in sight," which is proved to exist, and which can be accurately measured and valued. This estimate will give the minimum cash value of the mine as far as developed.

The other estimate should be based on reasonable probabilities as to the future, and will represent a value more or less speculative.

Conservative engineers usually confine themselves to the valuation of the mineral "in sight," and take no account of probabilities. Nevertheless, the speculative or probable future value of the mine will have weight with the intending purchaser or investor. He, or some one for him, will make some kind of an estimate of this probable value. Such estimates are likely to be exaggerated, and may work great harm. An estimate of the speculative value of the property, made by an expert who is able to weigh the probabilities intelligently, will enable the purchaser to decide the amount of risk he is justified in taking. Careful estimates of this kind

* *Trans. Am. Inst. Mining Engineers*, vol. x., pp. 288-293.

† The word "mineral" in this article will be used to cover productive vein rock, and ore, as mined, as well as coal, iron ore, rock-salt, etc.

will tend to prevent extravagant valuations from obtaining foothold, and will tend to discourage the over-capitalization of mining enterprises which has worked so much injury to the mining industry of the country.*

WORK OF EXAMINATION.

The examinations to obtain the necessary data for the valuation of the mine will be, so far as the surface is concerned, on the same lines as the preliminary survey detailed in the last article. If there has been no such preliminary examination of the property a topographical and geological survey should be made, following the scheme of work as previously outlined. This survey and examination can be complete and thorough, as the work of exploration and development have made the deposit accessible at all points.

In the examination of the property the following outline of work should be followed:

1. Study carefully the deposit and its associated rocks and minerals at numerous points, and determine its geological character. Determine, if possible, the method of its formation, especially when this is likely to have important bearing on the questions of regularity and continuance of the deposit. Specimens should be obtained for lithological study, if this is likely to throw additional light on the formation of the deposit or on the occurrence of the useful mineral.
2. Study and map the zones of rich and barren ground, the "pay chutes," "bonanzas," "ore-courses," "chimneys," "horses," "faults," "squeezes," etc., and endeavor to determine the laws governing the distribution of such zones and their average size and frequency of occurrence, as well as the relative areas of good and bad ground.
3. Make careful measurements, at as many points as possible, of the thickness of the deposit and of its different subdivisions or benches. Obtain the data to compute amount of mineral "in sight."
4. Make a survey of the underground workings, and construct sections to exhibit the data obtained and as a basis for the study of the deposit.
5. Obtain from different parts of the mine a sufficient number

* See also *Practical Mining* by J. G. Murphy, E.M. D. Van Nostrand, 1890.

of samples for assay to give an accurate determination of the average richness or quality of the mineral. The samples should be so taken as to show variations in richness or quality in the different parts of the deposit, in zones, layers or benches, as well as in different parts of the mine. If any mineral has been mined, and is accessible in cars, bins or stock-piles, this should be sampled. If any of the mineral has been sold, or treated in dressing or smelting works, secure data as to the results obtained.

6. Study the deposit and the enclosing rocks and overlying strata from the standpoint of the practical miner, and note conditions likely to have influence on the methods and cost of developing and working the mine, on drilling, blasting, timbering, drainage, ventilation, etc.

7. Determine the proper scale of operations, and estimate the amount of capital required.

8. Obtain data for estimating the cost of mining and mechanical preparation of mineral, probable cost of labor and supplies, sources and cost of fuel, timber, water, etc.

9. Determine proper metallurgical treatment and estimate cost of same.

10. Ascertain cost of transportation of supplies and product, and whether liable to change.

11. Study the market for the product; note the effect of increased production or competition on selling price.

12. Inquire as to the history of similar enterprises in the vicinity and commonly received opinions as to the richness and quality of mineral that can or cannot be worked.

(To be continued.)

A GRAPHICAL METHOD OF SHOWING THE RELATIVE ANNUAL EFFICIENCY OF A STEAM PLANT.

By H. F. J. PORTER, M.E.

If we examine the work performed by a large boiler plant we will find that the greater portion of the steam generated is utilized for one specific purpose, while small amounts are used only incidentally. For instance, in a heating plant, the bulk of the steam is used for the purpose of warming certain rooms or build-

ings while smaller amounts drive machinery for making repairs, for electric lighting, for pumping water and for minor purposes. In a factory most of the steam is used for power to drive machinery, and minor amounts are used for heating, pumping water and for special purposes.

It is the duty of the engineer to so arrange his plant that the steam for minor uses should be either waste steam or steam which can be utilized afterwards for doing its share of the main work of the plant.

When a plant is so arranged the cost of the minor uses of its steam is minimized and the main use to which it is put becomes the sole function of the expense of running. Thus, in a heating plant, the expense of running would depend upon and be inversely as the outside temperature, while in the power plant of a factory it would depend upon and vary directly as the output of the factory. We thus obtain a standard to which the running of the plant can at all times be referred.

In order to make the necessary comparisons careful records must be kept of temperature or output, as the case may be, and of the running expenses, and these must be systematically tabulated.

The graphical method of showing the results of tabulation has of late been made much of because it places them before the eye much more explicitly than mere columns of figures.

In this paper I shall endeavor to show by this method the rate of coal consumption in the heating plant of Columbia College, comparing it with the outside temperature. A similar method may be used to show the efficiency of any steam plant, measuring it by the output.

Until the fall of '84 no records of coal consumption at the college had been kept, and if they had, the frequent additions of new buildings and consequently boilers, would have made the records specific rather than relative, and therefore useless for the present purpose.

During the summer of '84 and the following winter the steam piping of the boiler house was completely overhauled and so arranged on a manifold system that the boilers could be used independently or together by any desired combination on any or all buildings, and the steam piping of the buildings was arranged so that the whole plant would work as a unit and not as a collection of units as before. The exhaust steam from all the engines, pumps,

etc., was turned into the heating mains and after performing its work of heating, all the steam was returned in the condition of condensed water, at a high temperature, to the boilers. Thus the cost of steam for power was made a minimum. So much help was obtained from the exhaust steam from the engines used for ventilating, electric lighting, pumping water, air, etc., that on dark days in winter when all the machinery was at work, the heating boilers were not run under pressure, and the buildings were heated almost entirely by exhaust steam.

Records were begun on Nov. 1, '84, but the work upon the re-arrangement of the plant did not cease until the following spring. During this time, however, the heating and lighting was not interrupted, but the plant was run in a manner that was not economical owing to its unfinished condition. The records show the relative economy of running before and after the plant was overhauled.

The coal burned previous to Nov. '84 was of the size known as broken or lump. During the year Nov. '84-Nov. '85 the size burned was egg. During the years Nov. '85-Nov. '89 pea coal was burned, and since then buckwheat.

It was anticipated before each change was made that more of the smaller size would be burned; not so much more, however, but that the difference in cost would show a considerable saving in favor of the smaller size. But it was gratifying to find, that less of the smaller coal was burned and the saving in cost from the first change was over 50 per cent. during the year. Since that time the area to be heated has considerably augmented, the electric lighting plant has grown to five times its original size and the engines for power have greatly increased in number and run all day long instead of occasionally. And yet the coal consumption has been less and at present is no greater than it was the year before the plant was overhauled, reckoning from the coal bills of that year.

The price of coal has varied considerably as will be seen by the tables, but in the graphical record this has not been considered, as it is but incidental to the question at issue. Coal strikes and blizzards, for instance, raise the price of coal, but do not affect the efficiency of the plant, which is the point under consideration.

In order that a proper record should be kept the following form of record sheet was printed and hung in the boiler house and has been filled out regularly ever since.

TEMPERATURE.														COAL.		REMARKS.	
Day of Week.	Day of Month.	Hours.												Average	Total.		Tally.
		6	7	8	9	10	11	12	1	2	3	4	5				
.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

The temperature has been taken hourly day and night from a thermometer hung in the shade outside of the boiler-house door, and a tally of the coal was kept by counting the coal trucks as they entered the boiler house from the coal vaults.

These trucks were always filled until they would hold no more. When so filled the coal weighed net 1600 lbs.

The hourly record of the temperature serves to apprise the firemen of an impending change in the weather and a comparison of the coal tally with the average temperature for the day shows the engineer whether or not his men have done their duty; for the same average temperature should be accompanied by the same rate of coal consumption, other things being equal, unless something has gone wrong with the plant.

These monthly records have been tabulated and are given herewith. They are more interesting when accompanied by the remarks from the monthly records showing the causes for certain irregularities and inconsistencies, but the limits of this paper do not allow the insertion of these details.

From these tables the curves have been plotted, one pair for each year, the dotted line representing the temperature and the continuous line the coal.

It will be seen, that as the temperature line rises it crosses the coal line and that there is really no relation between the two during the summer months when there is no heating, but at which time, considerable power is required for electric lighting, running machinery for repair shop, pumping water, ventilating, etc.

The relative efficiency when referred to the outside temperature is therefore to be considered between the curves only before and after the intersections of these lines.

It is the desire of the engineer, in order to obtain the greatest efficiency from the plant, to keep parallelism between the curves and to have them as far apart as possible. In other words the plant should be run, *first*, so that all the steam should be used for heating and thus the coal curve will rise and fall with the temperature curve; and *second*, so that the minimum coal should always be burned and thus for any given point on the temperature curve the corresponding point on the coal curve would be at a great distance from it.

The ratio between the areas circumscribed by the curves determines a value for the efficiency of the plant for the year, and it will be seen that each year has been given its appropriate figure. The greater this figure the better the running of the plant.

The areas have been taken by the planimeter and the part enclosed by the intersections of the curves has been deducted as irrelevant.

As has been already remarked the reading of the curves loses interest and even intelligibility when unaccompanied by the reasons for the apparent erratic changes in their direction, but as I have attempted to show only the method of keeping the record it has not been deemed necessary to enter into these details.

I.*

1883-1884.

Months.	Mean Temp.	FUEL.		Cost Per Ton.	Days.	Rate Per Day.	Total Cost.
		Amt. G. T.	Kind.				
November	Degrees.	.....	Lehigh Lump	.....	...	.....	.....
December	43.74	.....	"	.....	...	.....	.....
January	31.98	.....	"	.....	...	.....	.....
February	24.69	.....	"	.....	...	.....	.....
March	34.01	.....	"	.....	...	.....	.....
April	37.67	.....	"	.....	...	.....	.....
May	48.10	.....	"	.....	...	.....	.....
June	59.80	.....	"	.....	...	.....	.....
July	71.25	.....	"	.....	...	.....	.....
August	71.93	.....	"	.....	...	.....	.....
September	73.71	.....	"	.....	...	.....	.....
October	72.03	.....	"	.....	...	.....	.....
Year	57.70	.....	"	.....	...	.....	.....
Year	52.21	1,122.08	Lump.	\$4.60	366	\$14.10	\$5,161.56

* Yearly mean of all months, not including June, July, August and Sept., 42.21°.

* No records were kept at this time, and the figures have been taken from the coal bills.

II.*
1884-1885.

Month.	Mean Temp.	FUEL.		Cost Per Ton.	Days.	Rate Per Day.	Total Cost.
		Amt. G. T.	Kind.				
	Degrees.						
November	40.22	180.00	Lehigh Egg.	\$4.60	30	\$27.60	\$828.00
December	33.64	232.14	"	"	31	34.41	1,067.84
January	29.41	398.57	"	"	31	44.39	1,373.42
February	22.74	300.71	"	"	28	49.40	1,383.27
March	30.62	271.42	"	"	31	40.28	1,248.58
April	49.39	113.57	"	"	30	17.41	522.42
May	59.86	63.57	"	"	31	9.43	292.42
June	70.96	10.00	"	"	30	1.53	46.00
July	78.49	8.57	"	"	31	1.28	39.42
August	72.35	9.28	"	"	31	1.38	42.78
September	64.38	11.43	"	"	30	1.75	52.58
October	54.11	64.28	"	"	31	9.53	295.68
Year	50.51	1,563.54	Egg.	\$4.60	365	\$19.71	\$7,192.41

Yearly mean of all months, not including June, July, August and Sept., 39.99°.

III.†
1885-1886.

Month.	Mean Temp.	FUEL.		Cost Per Ton.	Days.	Rate Per Day.	Total Cost.
		Amt. G. T.	Kind.				
	Degrees.						
November	44.93	108.57	Lehigh Egg. 24.41 84.16	\$4.60	30	\$11.60	\$347.934
December	35.70	185.70	Lackawana Pea. Lackawana Pea.	2.80 2.80	31	16.77	519.960
January	26.79	235.71	"	"	31	21.28	659.988
February	27.45	198.57	"	"	31	19.85	555.996
March	37.60	155.00	"	"	31	14.00	434.000
April	52.87	80.00	"	"	30	7.46	224.000
May	60.18	38.57	"	"	31	3.48	107.996
June	68.03	9.28	"	"	30	.86	25.984
July	74.83	8.57	"	"	31	.774	23.996
August	70.19	8.57	"	"	31	.774	23.996
September	65.25	10.00	"	"	30	.93	28.000
October	54.90	54.29	"	"	31	4.90	152.012
Year	51.56	1092.83	Pea.	2.84	365	\$8.504	\$3,103.86

Yearly mean of all months, not including June, July, August and Sept., 42.558°.

* During this year the plant was undergoing reconstruction.

† The figures show the effect of the work of reconstruction of the previous year.

IV.*
1886-1887.

Month.	Mean Temp.	FUEL.		Cost Per Ton.	Days.	Rate Per Day.	Total Cost.
		Amt. G. T.	Kind.				
November.....	44.56	71.60	La. Pea.	\$2.80	30	\$10.28	\$307.541
		36.97	Lh. Pea.	2.95			
		<u>108.57</u>					
December.....	29.59	230.71	Lh. Pea.	2.95	31	21.95	680.690
January	29.09	38.10	Lh. Pea.	2.95	31	26.44	819.759
		3.00	L. & W. Pea.	3.75			
		7.00	Lh. Nut.	3.75			
		10.00	Lh. Egg.	5.00			
		120.20	La. Egg.	4.80			
		13.84	Plymouth Pea.	3.10			
		<u>192.14</u>					
February.....	33.63	7.16	Ply. Pea.	3.10	28	28.76	805.308
		121.95	La. Egg.	5.60			
		32.32	Ply. Pea.	3.10			
		<u>161.43</u>					
March	32.25	42.68	Ply. Pea.	3.10	31	20.73	642.656
		23.00	Ply. Egg.	4.50			
		104.32	La. Buckwt.	3.90			
		<u>170.00</u>					
April	46.33	17.62	La. Buckwt.	3.90	30	10.14	304.162
		75.95	Ply. Pea.	3.10			
		<u>93.57</u>					
May	63.75	30.71	Ply. Pea.	3.10	31	3.07	95.201
June.....	69.60	16.43	"	4.10	30	2.24	67.363
July.....	78.18	15.71	"	4.00	31	2.02	62.840
August.....	70.01	17.86	"	4.00	31	2.30	71.440
September	61.82	25.00	La. Pea.	4.20	30	3.50	105.000
October	52.17	70.00	"	4.20	31	9.48	294.000
Year.....	50.91	1,132.13	Pea.	3.76	365	\$11.66	4,255.961

Yearly mean of all months, not including June, July, August and Sept., 41.42°.

* A coal strike considerably affected the price of coal during this year and the first part of next.

V.*

1887-1888.

Month.	Mean Temp.	FUEL.		Cost Per Ton.	Days.	Rate Per Day.	Total Cost.
		Amt. G. T.	Kind.				
	Degrees.						
November	41.40	117.14	L. a. Pea.	\$4 20	30	\$16.39	\$491.980
December	33.81	167.14	"	4 20	31	22.64	701.988
January	22.97	247.86	"	4.20	31	33.58	1,041.012
February	29.30	183.57	"	4.20	29	26.58	770.994
March	29.99	209.28	"	4.20	31	28.35	878.976
April	46.03	97.14	Wy. Pea.	3.95	30	12.79	383.700
May	58.02	66.43	"	3.95	31	8.46	262.398
June	70.85	28.57	"	3.95	30	3.76	112.851
July	70.71	19.29	"	3.95	31	2.45	76.179
August	72.56	17.14	"	3.95	31	2.18	67.714
September	62.81	17.86	"	3.95	30	2.35	70.567
October	48.61	94.28	L. a. Pea.	3.90	31	11.89	367.692
Year	48.92	1,265.70	Pea.	4.13	366	14.30	5,226.051

Yearly mean of all months, not including June, July, August and Sept., 38.77°.

VI.

1888-1889.

Month.	Mean Temp.	FUEL.		Cost Per Ton.	Days.	Rate Per Day.	Total Cost.
		Amt. G. T.	Kind.				
	Degrees.						
November	45.45	110.00	L. a. Pea.	\$3 90	30	\$14.30	\$429.00
December	34.74	160.71	"	"	31	20.72	626.77
January	35.74	152.85	"	"	31	19.23	596.11
February	27.75	198.57	"	"	28	27.66	774.42
March	39.74	158.57	"	"	31	19.94	618.42
April	51.21	105.00	"	"	30	13.65	409.50
May	63.53	59.28	"	"	31	7.40	231.19
June	70.47	18.57	Pittston Pea.	3.10	30	1.91	57.56
July	73.21	2.00	L. a. Pea.	3.90	31	.25	7.80
August	70.55	0.00	.....	.....	31	.....	.....
September	65.10	16.43	L. a. Pea.	3.90	30	2.14	64.08
October	49.72	83.57	"	"	31	10.56	325.92
Year	52.27	1,065.55	Pea.	\$3.88	365	\$11.35	4,140.77

Yearly mean of all months, not including June, July, August and Sept., 43.49°.

* The cold weather of January and the blizzard of March appreciably affect the averages for this year.

VI.
1889-1890.

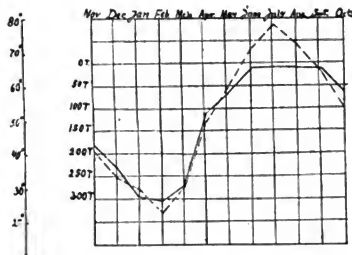
Month.	Mean Temp.	FUEL.		Cost Per Ton.	Days.	Rate Per Day.	Total Cost.
		Amt. G. T.	Kind.				
November.....	Degrees. 44.74	79.14	I. a. Pea.	\$3.90	30	\$12.73	\$382.14
December	39.97	148.57	Pitts. B'ckw't.	3.10	31	14.85	460.56
January	37.62	167.14	"	"	31	16.71	518.13
February	37.93	158.57	"	"	28	17.56	491.56
March.....	35.59	212.14	"	"	31	21.21	657.63
April.....	49.07	110.71	"	"	30	11.44	343.20
May.....	60.25	64.29	"	"	31	6.43	199.30
June.....	70.08	17.86	"	"	30	1.85	55.37
July.....	73.12	10.71	"	"	31	1.07	33.20
August.....	72.74	13.57	"	"	31	1.36	42.07
September	67.13	17.14	"	"	30	1.77	53.23
October	54.50	100.00	L. & W. B'ckw't.	2.55	31	10.00	255.00
Year.....	53.52	1123.55	Buckwheat.	\$3.11	365	9.71	3491.39

Yearly mean of all months, not including June, July, August and Sept., 44.96°.

RECAPITULATION.

Years.	Yearly mean of all months, not including June, July, August, and September.	Amount Gross Tons a Year.	Cost per Ton.	Rate per Day.	Total Cost Per Year.	Efficiency obtained from the Diagrams.
1883-1884.	42.21°	1,122.08	\$4.60	\$14.10	\$5,161.56	.....
1884-1885.	39.99°	1,563.54	4.60	19.70	7,192.41	1.1056
1885-1886.	42.55°	1,092.83	2.84	8.50	3,103.86	1.2250
1886-1887.	41.42°	1,132.13	3.76	11.66	4,255.96	1.3500
1887-1888.	38.77°	1,264.05	4.13	14.30	5,226.05	1.2570
1888-1889.	43.49°	1,065.55	3.88	11.35	4,140.77	1.1840
1889-1890.	44.96°	1,123.35	3.11	9.71	3,491.39	1.2000

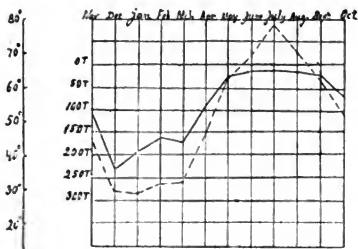
1884-1885



----- Temp. Curve
 _____ Coal Curve

Ratio 1 : 1.1056.

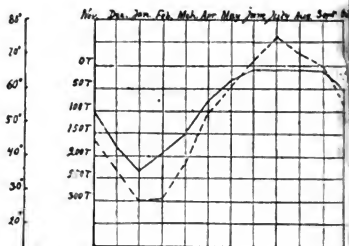
1886 - 1887.



----- Temp. Curve.
 _____ Coal Curve.

Ratio 1 : 1.3500.

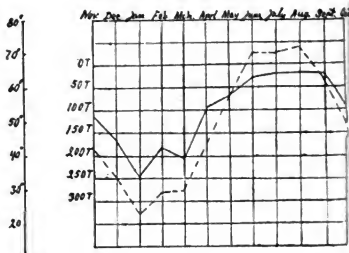
1885 - 1886



----- Temp. Curve
 _____ Coal Curve

Ratio 1 : 1.2250.

1887-1888

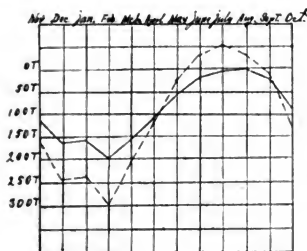


----- Temp. Curve
 _____ Coal Curve

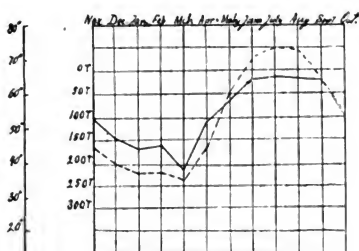
Ratio 1 : 1.2570.

1888-1889

1889-1890



----- Temp. Curve
 _____ Coal Curve
 Ratio 1 : 1.1840.



----- Temp. Curve
 _____ Coal Curve
 Ratio 1 : 1.2000.

NOTE.—The areas of these curves were computed from diagrams laid out to a very much larger scale than the above, to obtain greater accuracy in measuring them by the planimeter.

NOTES ON A RED SEDIMENT FORMED IN A RAFFINOSE SOLUTION.

By F. G. WIECHMANN, PH. D.

WHILE engaged in the isolation of raffinose from a low beet-sugar, the writer incidentally obtained from the raffinose solution, a precipitate bright red in color, and of peculiar properties, which he has so far been unable to identify as one of the numerous substances whose occurrence in saccharine solutions has been established.

The incident seemed sufficiently curious to merit recording, and although the amount of the substance secured was, unfortunately, too small to permit of ultimate analysis or of an exhaustive investigation, a brief history of the case, and a description of the properties of the body, as far as determined, may prove of interest.

The raw material used for the preparation of the raffinose was

an after-product from a German beet-sugar factory employing the Strontianite process.

The sugar presented a highly crystalline appearance, and exhibited in profusion the needle formation, characteristic of products containing raffinose. In color it was of a dark brown. The analysis, made in duplicate, showed:

Polarization,	93.6	93.7
Sucrose,	88.2	88.3
Raffinose,	2.9	2.9

Work was commenced on November 23, 1888. The different steps taken, were as follows:

To 6000 grammes of raw sugar there were added 6000 c.c. methyl alcohol.

The solution was after some time drained off, and the sugar treated with an additional 4000 c.c. of methyl alcohol.

From the 10,000 c.c. alcohol added, about 7400 c.c. were recovered.

This solution was placed on a water-bath and the alcohol evaporated completely.

When this had been accomplished, and while the solution was still warm, ethyl alcohol was added until a *permanent* turbidity was caused.

This precipitate was allowed to settle and was then separated from the clear solution.

This operation was performed six times; the time allowed for settling being in each instance about 2 days.

Then the raffinose syrup, perfectly free from alcohol, was drawn off.

This syrup amounted to 200 c.c. and was divided into three portions.

As the colored sediment was produced in only one of these portions, a brief statement of the treatment which each of these portions received, is given.

PART I. 20 c.c. were devoted to a trial of Scheibler's method for preparing raffinose.*

Treatment was commenced January 16, 1889, and by September 5, 1889 the separation of the raffinose crystals seemed complete.

* *Zeitschrift des Vereines für Rüben-zucker Industrie*, 1888, p. 337.

PART II. 50 c.c. were treated as follows :

The specific gravity of the syrup was determined to be 1.4022.

To the 50 c.c. (70.11 grammes) there were added 140.22 grammes acetate of lead. Then absolute ethyl alcohol was added and the solution heated on a water-bath.

The precipitate which formed, was filtered out, suspended in water, and sulphuretted hydrogen was passed in until complete precipitation of the lead had been accomplished.

The sulphide of lead was filtered out and thoroughly washed with water. The filtrate was evaporated on a water-bath to the consistency of a thick syrup. This was dissolved in very little water, and when cold, ethyl alcohol was added, drop by drop, until the turbidity just continued to disappear. The flask into which the solution had been placed was well corked and set aside to allow the crystallization of its contents. On March 28, 1890, there was considerable of a white crystalline deposit in the bottom of the flask, and the sides of the flask were completely studded with warts of raffinose.

PART III. On March 28, 1890, work was commenced on the balance of the 200 c.c. previously referred to, and it was in this portion that the colored sediment was developed.

The specific gravity of the solution was 1.30642. To 97 c.c. of this solution (126.7227 grammes), 253.4455 grammes of acetate of lead were added. Ethyl alcohol was then added and the solution was heated on a water-bath.

This treatment was repeated until all of the raffinosate of lead had been precipitated.

This precipitate was then filtered out, suspended in water and sulphuretted hydrogen gas was passed in until all of the lead had been thrown down.

The sulphide of lead was filtered out and was thoroughly washed with cold water. This was continued until the washings no longer polarized.

To the filtrate, blood-carbon of the best quality was added ; this was thoroughly shaken up with the solution, allowed to remain in it for about 12 hours, and then filtered off from the then almost colorless liquid. The blood-carbon was then washed with water until the washings no longer polarized.

The washings were added to the filtrate and the whole evapor-

ated, at a temperature of about 70° to 75° C., under partial vacuum, to the thickness of a syrup.

This syrup reacted decidedly acid, and upon testing, sulphuric acid was found to be present. This acid was exactly neutralized with barium hydrate and the precipitate of barium sulphate was filtered out. The filtrate, which was of a light amber color, was concentrated to a thick syrup by evaporation in partial vacuum.

The solution again turned dark and again reacted slightly acid. Barium hydrate was once more added to neutralization; an additional quantity of the best blood-carbon was also placed in the liquid, and the whole was allowed to stand at rest for four days.

The solution was then filtered through asbestos, washed slightly with water and set aside.

It would now have needed only the addition of ethyl alcohol and a leaving at rest to secure the crystallization of the raffinose.

When set aside the solution was perfectly clear and of a light brownish color. After allowing it to stand well corked for 24 hours, on close inspection, it was found to contain a bright red sediment, in color not unlike red sealing-wax. On moving the solution the sides of the glass vessel were seen to be coated with a beautiful rose-colored film.

The solution looked at by transmitted light was of a brownish-yellow color; by reflected light the solution was opaque and of a very dark green color, resembling in appearance the heavy oils of petroleum; looking across the surface, films of emerald-green and rose were visible.

The solution was allowed to stand well corked, and at rest, for seven days, during which period the sediment increased.

At the end of this time the sediment was filtered out, the filtrate being passed into a covered flask in order to avoid exposure to the atmosphere.

This filtration yielded a perfectly clear brownish-yellow solution which had lost every trace of fluorescence. This filtrate, well corked, was set aside (June 18th), in order to learn whether any more of the colored sediment would be developed in it.

This solution will hereafter be referred to as specimen A.

The sediment, all of which had been retained by the filter-paper, was of a bright-red color, resembling in tint, as already stated, ordinary red sealing-wax. By reflected light it exhibited an emerald-green sheen.

This sediment will hereafter be referred to as specimen B.

To remove all raffinose solution adhering to the filter-paper the sediment B was washed moderately with distilled water. The washings were caught and kept in a separate flask.

These washings were preserved for three months and no sediment having formed in them, they were then discarded.

The filtrate (A) was inspected from time to time. The following are some of the entries recorded:

June 18th.—Solution perfectly clear; color brownish-yellow; no fluorescence.

June 19th.—No change.

June 20th.—Distinct though thin layer of sediment has formed, adhering uniformly to all parts of the glass in contact with the liquid.

June 21st.—Sediment slightly increased. A green fluorescence of the solution is noticeable.

June 23d.—Sediment increasing. Distinct rose layers on sides of vessel. The solution is brownish-yellow by transmitted light, and dark green by reflected light.

These observations were continued through July and August. The rose-colored sediment in the solution gradually changed in color to a rich brown. At the beginning of September it was noticed that white round disks, which seemed to be mould formations, appeared floating on the surface of the solution. Fearing a possible destruction of the colored precipitate at the bottom of the flask, these disks were removed and the sediment filtered out.

This sediment was marked specimen C.

The solution after the sediment had been filtered out, was of a dark-brown color, and without any fluorescence.

It was treated with absolute ethyl alcohol, and after standing a few hours yielded a copious brownish-gray precipitate which should, and probably will prove to be, raffinose. This precipitate, however, yet awaits purification and recrystallization from alcohol.

The red sediment first obtained, specimen B, was for months preserved practically unchanged. It was kept on the original filter-paper, of course carefully protected from the dust.

Examined under the microscope with low powers ($\frac{3}{4}$ and $\frac{1}{2}$ objectives with respectively the A, B and C eye-piece) the substance exhibited an appearance like scales, partly round, partly angular; no crystalline system could be distinguished.

When submitted to examination by a Zeiss immersion lens the sediment was found to consist of small plates and rod-like formations.

It was impossible to determine with certainty whether the rod-like formations were bacteria, or of crystalline structure.

The deposit is however, probably, a chemical precipitate. Dr. A. A. Julien, who also kindly examined the specimen, expressed this view, which is strengthened by the following considerations:

1. The sediment was formed in the liquid, preferably on the sides and bottom of the flask, whereas most chromogenic bacteria are aërobic, and hence would display greatest activity at the surface of the solution.

2. The sediment is insoluble in alcohol, whereas bacteria colors are soluble in this reagent.

3. The rods vary considerably in size, whereas bacteria would exhibit fairly uniform dimensions.

As this colored sediment was not formed in either of the two preceding portions of the raffinose solution, but only occurred in that portion which was decolorized with blood-carbon, it was natural to suspect that this reagent might have been the source of the sediment in question.

Hæmatin was looked for in a hydrochloric acid solution by the spectroscope (absorption bands), but with negative result.

Attempts were then made to obtain hæmatin from some of the blood-carbon by treatment with acetic acid and ether. This also failed to yield even a trace of the substance sought.

The supposition that this sediment is hæmatin will, therefore, have to be abandoned, although some of the reactions given further on would point to a body of this nature.

Subjecting the blood-carbon to treatment with twenty times its volume of 75 per cent. alcohol, and subsequent addition of barium hydrate—a repetition of the conditions of the experiment, but in the *absence* of the raffinose syrup—also failed to produce the colored sediment, thus proving that these reagents alone could not have given rise to its existence.

Various reagents were tried in the attempt to find a solvent for the sediment. It was found to be:

Soluble in hydrochloric acid, concentrated.

Soluble in nitric acid, concentrated.

Soluble in sulphuric acid, concentrated.

Insoluble in acetic acid, concentrated.

Insoluble in turpentine.

Insoluble in ethyl alcohol.

Insoluble in methyl alcohol.

Insoluble in water.

Insoluble in sucrose solution, concentrated.

Insoluble in ether.

Insoluble in ammoniac hydrate, concentrated.

A test made with a hydrochloric acid solution of the sediment showed it to be inactive to polarized light.

On burning some of the substance on platinum foil a small residue remained; this gave a distinct reaction for iron, an impurity introduced by the barium hydrate which had been used for neutralization.

Tests made on the hydrochloric acid solution of the sediment proved the presence of barium and iron, and the absence of calcium, potassium and sodium.

In the absence of data obtained by ultimate analysis it would be idle to speculate on the nature of this substance, remarkable for its fluorescence and brilliant color. As, however, its properties seem to differ from those of any body known to occur in saccharine solutions, it seems permissible to assume, that it is either some substance hitherto entirely unknown, or else a new derivative or compound of raffinose.

THE WIND PROBLEM IN GUNNERY.

By LIEUT. JOHN W. RUCKMAN, U.S.A.

(Continued from Vol. XI., p. 328.)

PART II.

Analytical Investigation.

THE preceding pages have been devoted to showing the inconsistencies of current theories and their inefficacy to explain the deviating effect of wind on a moving projectile. The following

pages will be occupied in investigating and discussing the problem from an entirely different standpoint. In this discussion wind-pressure does not appear, and the writer does not hesitate to assert that the wind cannot produce side pressure on a moving projectile. That is, pressure as would appear upon the side of the projectile if at rest.

Before going directly to the effect of wind upon a moving projectile, a few familiar examples will illustrate and simplify the subject and help to introduce it. Let us take the case where rain is falling straight downward. We all know that if we run rapidly through it, the drops will strike us from in front and downward. No drops can then strike us directly from above. The inclination to the front will depend upon our own rate of speed, and could we move so fast that our own motion would be great compared to that of the falling drops, they would strike us almost directly in front.

The same effect may be witnessed on a ship when a wind is blowing across her course. A pennant attached to her mast assumes a position which does not coincide with the direction of the wind nor with that of the ship's motion, but takes up a direction which is the resultant of the wind's velocity and the apparent backward motion of the air.

A similar effect in astronomy is known as the aberration of light. The light wave from a heavenly body advances toward the earth at the rate of 185,000 miles per second. The earth's orbital velocity, though small compared to that of light, is still appreciable. An eye moving with the earth cannot receive the direct ray from the star, but must receive the light from a point in the light wave slightly in advance of the earth. This point will be found on the resultant of the velocity of light and the relative backward motion of the luminous undulations in front. The backward motion is equal to the earth's orbital velocity.

Were the velocities of the earth and light interchanged the star would be displaced nearly 90° .

Now, what takes place in the preceding examples is similar to what must take place with the air's side motion when taken in conjunction with the forward motion of a projectile in flight.

The wind has a velocity V_w and is blowing obliquely to the plane of fire. Let the angle it makes with this plane be denoted by ϕ . The air, therefore, has a proper motion of its own and the

particles impinge upon the projectile with a velocity V_w . At any point in the trajectory the air will also be impinging upon the projectile directly in front with a velocity equal to that in the projectile. Thus we see that the air has two motions: the one relative and in the direction opposite to that of the projectile, the other along the direction of the wind.

These two distinct velocities are *the components of a resultant velocity of impingement*.

This resultant velocity is easily determined. Construct a parallelogram upon the two component velocities of impingement. The diagonal of this figure gives the intensity and direction of the resultant. The resultant resistance to the projectile's motion acts along this line, and is consequently oblique to the line of the projectile's motion. The angle between the direction of the projectile's motion and the resultant resistance is here called "the obliquity of the resultant."

Thus disregarding all reactions of the particles among themselves, we consider the air as a moving fluid which impinges upon the projectile along a certain line and with a definite resultant velocity.

The oblique resultant velocity and resistance briefly express the theory whose development and elucidation will now be given.

Taking this brief statement as the fundamental principle, we shall discuss the problem analytically and deduce the laws which result therefrom, and shall point out the method of applying them practically to the problem now before us.

Denote the projectile's remaining velocity by v and resultant velocity by V_r and we obtain from the parallelogram of velocities

$$V_r = \sqrt{v^2 + V_w^2 + 2v V_w \cos \delta}.$$

$\cos \delta$ will be positive when the wind's direction falls in the first or fourth quadrant, and negative when it falls in the other two. The resultant resistance being oblique to the projectile's motion has a component perpendicular to its path which constantly acts as a deviating force. It is clear that under the action of this component the projectile must depart more and more from the plane of fire.

In order to express the different quantities mathematically, let R be the general expression for the resistance and $R_1, R_2, R_3, \dots, R_n$ the mean resistances over the 1st, 2d, 3d, \dots nth hundred yards respectively.

Denoting the angle of obliquity by φ , then $\varphi_1, \varphi_2, \varphi_3 \dots \varphi_n$ will correspond to $R_1, R_2, R_3 \dots R_n \dots$

In Fig. 2 construct parallelograms of resultant velocities at $B_1, B_2, B_3 \dots$ etc. The sides of the parallelograms are the corresponding remaining velocities of the projectile and the constant velocity of the wind.

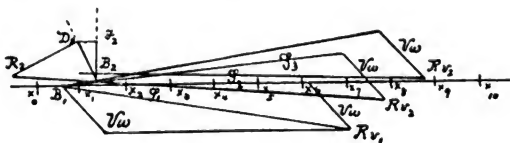
At B_2 the following relations are easily obtained: $R_2 \cos (90^\circ - \varphi_2) = B_2 D_2$, and $B_2 D_2 \cos \varphi_2 = B_2 F_2 = P_2$, the deviating component at B_2 . Again, $\cos (90^\circ - \varphi_2) = \sin \varphi_2$, and $P_2 = R_2 \sin \varphi_2 \cos \varphi_2$

$\sin \varphi_2 \cos \varphi_2 = \frac{1}{2} \sin 2\varphi_2$, and $P_2 = \frac{1}{2} R_2 \sin 2\varphi_2$.

At B_3 , similarly $P_3 = \frac{1}{2} R_3 \sin 2\varphi_3$, and generally $P = \frac{1}{2} R \sin 2\varphi$.

Now, as the wind is invariable in direction, and as P is constantly moving the projectile away from the plane of fire, the pro-

FIG. 2.



jectile, always moving tangentially to its trajectory, will be gradually changing its direction with respect to that of the wind.

Thus, if the wind be blowing perpendicularly to the plane of fire, the projectile's motion will soon make a small angle with that plane and δ will no longer be 90° .

Although this does actually take place in practice, the change will always be so small that it may be neglected; for the range must always be great compared to the deviation, and the angular departure will be small. At a range of 3500 yards, 150 yards deviation will give an angular change of $2^\circ 30'$. We know from experience that for the 15-inch solid shot not less than a sixty-mile wind, blowing directly across the range, would be required to give a 150 yard deviation. In such a wind the apparent angular change in the wind's direction will not be more than $2^\circ 30'$. Now, let us see how much such a change will affect the deviating component of the wind's velocity. To do this we have only to multiply 60 by the cosine of $2^\circ 30'$, or $60 \times 0.99905 = 59.943$ miles. This

differs from 60 by 0.057 of a mile, a quantity probably less than the ordinary anemometer will register.

As the wind's velocity decreases the error will be less in the same proportion, and also from the cosine of the change being nearer unity. For a thirty-mile wind, blowing as above, let us assume 75 yards deviation, giving $1^{\circ} 15'$ change; then $30 \times 0.99976 = 29.9928$ miles deviating component.

When the wind's direction falls close to the plane of fire changes $n\delta$ are of greatest importance, but in such cases the deviations will always be small and the angular change almost nothing.

These illustrations show conclusively that in the following discussion the projectile may, without material error, be considered as always moving in, or parallel to, the plane of fire.

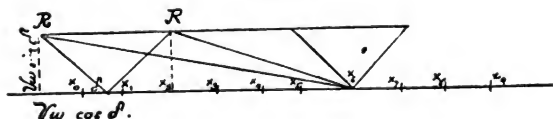
The obliquity of the resultant will, therefore, be found under the supposition that the wind's direction remains unchanged during the flight of the projectile.

Although the angular change just mentioned does not appreciably affect the obliquity of the resultant, there *is* a cause which constantly changes its value. From the parallelogram of velocities, Fig. 3:

$$\sin \varphi = \frac{V_w \sin \delta}{\sqrt{v^2 + V_w^2 + 2 v V_w \cos \delta}}, \text{ or the deviating component}$$

of the wind's velocity divided by the resultant velocity. In this value of the $\sin \varphi$, v is the only variable. During the flight v continually decreases, and φ and $\sin \varphi$ continually increase. The

FIG. 3.



resulting resistance, being a function of some power of V_R , will decrease with v . Thus, we see that while the resultant resistance is rapidly decreasing with v , the angle of obliquity is increasing. The deviating component is always varying with the product of the two.

For all values of v , with modern guns, $\sin \varphi$ will be very small.

For example, in a sixty-mile wind, making a right angle with the plane of fire, the deviating velocity of the wind is 88 feet. This deviating velocity, taken with a remaining resultant velocity of 880 feet, gives $\sin \varphi = 0.1$. When the wind makes an angle of 45° with the plane of fire $V_w \cos \delta$ and $V_w \sin \delta$ are each equal to $88 \times 0.70711 = 62.23$ feet.

Taking v at 1000, when the wind blows into the first or fourth quadrant, \sin of $\varphi = 0.0585$. When in the other quadrants, two and three, $\sin \varphi = 0.06625$. It will be observed that both these values are less than 0.1. We will, therefore, take 0.1 as the superior limit for $\sin \varphi$.

Referring to a table of natural sines, we find that $\sin 5^\circ 44'$ is 0.09990, or about 0.1. The sine of double this angle ($\sin 11^\circ 28'$) is 0.19880. Then half this, or 0.09940, is $\frac{1}{2} \sin 2 (5^\circ 44')$. Now, $0.09990 - .09940$ is equal to 0.0005. In this extreme case we see that $\sin \varphi$ and $\frac{1}{2}$ sine of twice φ differ only by 0.0005. It is, therefore, plain that for all values of φ and $\sin \varphi$, with which we have to deal in practice, $\sin \varphi$ may be substituted for $\frac{1}{2} \sin 2 \varphi$ without appreciable error.

Making this substitution in $P = \frac{1}{2} R \sin 2 \varphi$ we have $P =$
 $R \sin \varphi = R \sqrt{\frac{V \sin \delta}{v^2 + V_w^2 + 2 v V_w \cos \delta}}$ for the force which constantly carries the projectile away from the plane of fire.

Since the resultant resistance acts along the line of resultant velocity, and since the inclination of this line can always be determined, the retarding and deviating forces can easily be computed. Ingalls' *Exterior Ballistics* gives the following formulas (Mayevski's) for the resistance to a spherical projectile. For velocities greater than 1233 feet $R = \frac{A}{C} \cdot \frac{w}{g} \cdot \frac{v^2}{r^2}$ in which the logarithm of A is 6.3088473 — 10; $C = \frac{\delta_1}{\delta} \cdot \frac{w}{cd^2}$. In these expressions $\delta_1 =$ standard density of air; $\delta =$ density at time of experiment; $w =$ weight of projectile in pounds; $d =$ diameter of projectile in inches; and c for spherical projectiles is equal to unity; $g = 32.16$; and v is the remaining velocity in the projectile.

For velocities less than 1233 feet R is equal to

$$\frac{A}{C} \frac{w}{g} \left(1 + \frac{v^2}{r^2}\right) v^2$$

in which $\log A = 5.6029333 - 10$; and $r = 610.25$ feet; other quantities same as above.

To adapt these formulas to the computation of the resistance when the wind enters the problem, it is only necessary to substitute $V_R = \sqrt{v^2 + V_w^2 + 2 v V_w \cos \delta}$ for v .

Making this substitution in the above formulas and multiplying R by $\sin \varphi$, we have:

$$R \sin \varphi = \frac{A w}{C g} V_R V_w \sin \delta \text{ for velocities above 1233 feet,}$$

and $R \sin \varphi = P = \frac{A w}{C g} \left(1 + \frac{V_R^2}{r^2}\right) V_R V_w \sin \delta$ for velocities below 1233 feet.

From Fig. 3 we have $\cos \varphi = \frac{v + V_w \cos \delta}{V_R}$, and for the retarding force we have $R \cos \varphi = \frac{A w}{C g} V_R (v + V_w \cos \delta)$, and

$$R \cos \varphi = \frac{A w}{C g} \left(1 + \frac{V_R^2}{r^2}\right) V_R (v + V_w \cos \delta)$$

for velocities greater and less than 1233 feet, respectively.

The formulas are quite similar. The difference between those giving the deviating and the retarding forces is that the last factors in each case are the deviating and retarding component velocities of the resultant velocity.

It will be noted that $V_w \sin \delta$ is also the deviating component of the wind's velocity.

So far theory has been adhered to closely, which indeed was necessary to thoroughly elucidate the subject. In some cases many minor considerations may be neglected. The application of the preceding discussion to the example taken in PART I. will illustrate the value of this investigation.

It is to be regretted that the data given in *Ordnance Note 191* are not sufficiently complete to allow a careful solution by the method just outlined.

Perhaps the best we can do now is to take the same gun and projectile fired under the present conditions. The charge for this gun (15-in. S. B.) is now 130 pounds of sphero-hexagonal powder giving an initial velocity of 1706 feet. Let us take the wind the same as in PART I.; Elevation 5° ; Range 3000 yds.

Let the range be divided into thirty equal parts, and the remain-

ing velocities and the times of flight corresponding to each of these divisions be determined. The mean remaining velocity over any section is taken as the mean of the velocities at the extremities.

Knowing the mean remaining velocities at the middle points of the sections and the direction of the wind at each of these points the corresponding resultant velocities and resistances are easily constructed. Lay off from the middle point of each section its mean remaining velocity in the direction of the projectile's motion, and through the extremity of this line draw a line parallel and contrary to the wind's direction, and on this line lay off the wind's velocity. The diagonal joining the extremities of these two distances gives the resultant velocity. These diagonals intersecting consecutively form an envelope which shows the direction of the resultant resistance for any point. From any point in the range draw a tangent to this curve and it gives the required direction.

We are now prepared to compute the ordinates of the wind curve. In order to do so the deviating force for the middle point of each hundred yards is determined. These pressures are found under the supposition that the mean velocities obtain during the projectile's short passage over the corresponding sections. The values of P found in this manner are assumed constant while acting during the times and over the spaces just mentioned. The deviations are in this manner integrated mechanically.

The wind velocity denoted by V_w is 14.667 feet per second.

Let us assume the following notation:

$v_a = 1706$, initial velocity.

$v_1, v_2, v_3, \dots, v_n$, the remaining velocities at 1st, 2d, 3d
 \dots and n th hundred yards respectively.

$P_1, P_2, P_3, \dots, P_n$, the deviating forces over the parts just
 mentioned.

$T_1, T_2, T_3, \dots, T_n$, the times of flight corresponding to
 $v_1, v_2, v_3, \dots, v_n$.

$t_1, t_2, t_3, \dots, t_n$, the intervals of time in which the projectile
 passes the sections corresponding to their subscripts.

$v'_1, v'_2, v'_3, \dots, v'_n$, the deviating velocities impressed upon
 the projectile in the times t_1, t_2, t_3 , etc.

$s_1, s_2, s_3, \dots, s_n$, the corresponding spaces.

$V'_1, V'_2, V'_3, \dots, V'_n$, and $S_1, S_2, S_3, \dots, S_n$, the
 total side velocities and spaces deviated in the times T_1, T_2, T_3 ,
 \dots, T_n .

From the nature of this notation $t_1 = T_1$; $t_1 + t_2 = t_2 + T_1 = T_2$; $t_3 + T_2 = T_3$; etc.

$v'_1 = V'_1$; $v'_1 + v'_2 = v'_2 + V'_1 = V'_2$; $v'_3 + V'_2 = V'_3$, etc.

$s_1 = S_1$; $s_1 + s_2 = s_2 + S_1 = S_2$; $s_3 + S_2 = S_3$, etc.

Resuming the equation,

$$P = -\frac{A}{C} \cdot \frac{w}{g} \sqrt{v^2 + V_w^2 + 2v V_w \cos \delta} (V_w \sin \delta).$$

Since $\delta = 90^\circ$, $\sin \delta$ will be unity and $\cos \delta = 0$; hence

$$P = -\frac{A}{C} \cdot \frac{w}{g} \sqrt{v^2 + V_w^2} (V_w).$$

Assuming a low remaining value for v , say 1000, the radical becomes

$$\sqrt{(1000)^2 + (14.667)^2} = \sqrt{1000215} = 1000.10.$$

From this it appears that for the small velocity of $v = 1000$ feet, the radical expression differs from v by a quantity so small that it can be neglected without materially affecting the result, and we may write v for $\sqrt{v^2 + V_w^2}$ in the value of P . This sub-

stitution gives the formula $P = \frac{A}{C} \cdot \frac{w}{g} v \cdot V_w$. A simple calculation will now give the values of $P_1, P_2, P_3 \dots P_{30}$. These are found to be 34.52; 33.51; 32.54; 9.41 pounds respectively.

Having the values of the deviating forces at the different points above mentioned, the values of v' and s are easily calculated from $\frac{P}{M} t = v'$, and $\frac{P}{M} \cdot \frac{t^2}{2} = s$. Following this method and making the necessary computations for 3000 yards, the total deviation S_{30} is found to be 54.264 feet, or, 18.038 yards; giving a coefficient of 1.81 yards.

Having found this deviation for a ten-mile wind, it may be interesting to use it in the formula $\frac{P_m \cdot T_m^2}{M \cdot 2} = S_{30} = 54.264$, and determine the value of P_m . Thus doing, P_m is found to be 23.2 pounds, and is the constant force which, acting for 8.125 seconds, will deviate the shot 18,088 yards. It may be remarked, also, that the mean of the thirty values, $P_1, P_2, P_3, \dots P_{30}$ is 20.42 pounds, or about three pounds less than 23.2. The correct deviation is there-

fore greater than that (15.95 yards) produced by the mean 20.42 pounds acting for the same time. This is the necessary result of the greater forces acting first, and impressing the greatest side velocities on the projectile at the start, the effect of which is conserved throughout the flight.

It is also worthy of note that the mean of P_0 and $P_{30\frac{1}{2}}$ is 22.15 pounds, and as a constant force during flight corresponds to 51.88 feet or 17.3 yards.

The value of v' for each hundred yards at the beginning is about 0.44 of a foot, but after about say a thousand yards, it decreases until at the 30th hundred yards the value of v'_{30} is about 0.24 feet. The total value of the side velocity is 10.8 feet. Computation shows that at 4000 yards the projectile has a side velocity of 13 feet, and at 5000 yards a velocity about the same as that of the wind. After this the side velocity goes on slowly increasing.

The computation of deviations by the method just described requires great labor.

This method of computing them elucidates clearly the theory and successive action of the wind and its effect upon the projectile, but a much easier and better method can be applied in the calculation of the tables requisite to give this discussion practical value.

It will be observed that the greater the value of v in the expression for the sine of φ the smaller φ becomes. For the remaining velocity with which modern projectiles move (especially rifle projectiles) φ and $\sin \varphi$ must be small, and $\cos \varphi$ differ little from unity. $R \cos \varphi$, except in very high winds and low remaining velocities, will be sensibly equal to R . Therefore, the retardation in velocity in passing over a short interval of space will be the direct measure for the effect of the resultant resistance over that distance. To find the deviating velocity impressed while the projectile is passing over the same space, it is only necessary to multiply the retardations found in the firing tables by $\sin \varphi$. The sum of these partial velocities will give the total deviating velocity. If for any reason it may be desirable to be absolutely accurate, we must multiply the retardations by $\tan \varphi$. To obtain the space described or value of S for any section, we have only to take the mean of total side velocities at the extremes of the section and multiply it by the time of passage. The sum of all these differential spaces gives the total deviation.

This is an elegant method of computing the projectile's deflection from the plane of fire. The practical effect is to make the projectile's deviation vary with its retardation.

Having given the preceding explanation of the theory advanced in this paper, we are now prepared to deduce some very interesting and important conclusions relating to the wind's effect upon the flight of a projectile.

$$P = \frac{A}{C} \frac{w}{g} \sqrt{v^2 + V_w^2 + 2vV_w \cos \delta} (V_w \sin \delta)$$

is the general equation for the value of the deviating component. As $\cos \delta$ will be positive when the wind strikes the projectile anywhere on its front, *i.e.*, striking it in the first or fourth quadrant, the value of the radical will be greater than it would be for v alone. When the wind blows upon the projectile from behind or strikes it in the second or third quadrant—except when $V_w^2 =$ or $> 2V_w v \cos \delta$, or when $V_w =$ or $> 2v \cos \delta$, the radical will be less than for v alone. $V_w \sin \delta$ for a given wind will be constant. It is clear, therefore, that the deviating forces are slightly affected independently of the deviating component of the velocity, and that the deviating force will be greater when the wind has a retarding component than when it has an accelerating one of the same intensity. It is also clear that the deviating force will increase more rapidly than the wind's deviating component for winds with retarding components, and less rapidly than the component for winds with accelerating ones. The effect of the terms in the radical will never be great except for enormously high winds. For low winds, as in the example just considered, where the radical differs inappreciably from v , P will be $= \frac{A}{C} \frac{w}{g} v V_w \sin \delta$.

In this equation P varies directly with $V_w \sin \delta$, the deviating component of V_w . Now $\frac{P}{M} = \frac{d^2 s}{dt^2}$ expresses the relation between the variable force P and the acceleration impressed upon the mass M . From this we see that the acceleration for the same mass will vary directly with the value of P . Therefore, as P varies the acceleration of the projectile sidewise varies directly with it. Acceleration being the velocity impressed in a unit of time, it follows that the spaces described must vary directly with acceleration and the accelerating force.

Thus, it follows that for all cases to which $P = \frac{A}{C} \frac{w}{g} v V_w \sin \delta$

applies, the pressure and deviations will vary directly with V_w . Therefore, if V_w increases to twice its original value, the deviation will be doubled. From this we obtain the rule that in moderate values for V_w , deviation varies directly with the velocity of the wind.

Now, passing on to higher winds, since, as just shown, the deviating force for head winds increases more rapidly than the velocity, deviation must follow the same laws, and for all winds with accelerating components the converse is true.

These deductions are independent of any increase or decrease in the time of flight.

The law that deviations are proportional to the wind's velocity, though not theoretically true in any case, will apply practically whenever $\tan \phi$ may be substituted for $\sin \phi$ without appreciable error. It is highly probable that all deviations follow this law so closely that no variation from it will be sensible in practice.

The Fish-tail Wind.—By this we mean a wind whose capriciously varying direction makes at any instant but a small angle with the plane of fire, changing constantly and quickly from one side to the other, as does a fish's tail in swimming.

Without doubt this is the most troublesome wind to riflemen and gunners. In such a wind it is almost impossible to obtain uniform results. The extreme changeability of its direction causes these well-known irregularities, but so far it never has been very clear why a change of a few degrees, when δ is small, should be so important, while the same change when δ is large is comparatively unimportant.

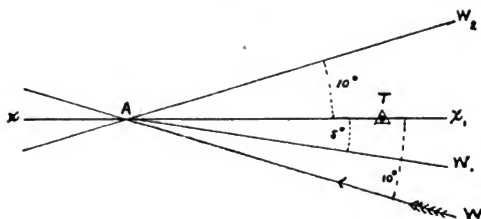
This apparent anomaly is clearly accounted for by the preceding theory, and is explained by the following considerations. We have seen that deviations vary almost directly with $V_w \sin \delta$. Now, if V be constant and δ be variable, as in the case of the fish-tail wind, the greatest change in the $\sin \delta$, for equal increments or decrements of δ , take place when δ is near 0° or 180° , or when the wind's direction is nearly coincident with the plane of fire. A few degrees change in δ , under such circumstances, will fully account for the apparent eccentricities of the shots.

A simple example will illustrate this.

In Fig. 4, AT represents the range. A is the position of the gun and T of the target. Let AT be three thousand yards. Let WA show the direction of the wind making an angle of 10° with

the plane of fire. Let V_w be 25 miles an hour. Then $25 \times \sin 10^\circ = 25 \times 0.17365 = 4.341$ deviating component. As shown, the coefficient for the 15-inch gun is 1.8 yards at 3000 yards range. Then $4.341 \times 1.8 = 7.81$ yards for the wind allowance, to the right. If, just after the gun is aimed and before it is fired the wind should change to W_1A , making an angle of 5° with AT , the wind allowance during flight should be only $25 \times 0.08718 \times$

FIG. 4.



$1.8 = 3.92$ yards. The projectile must then fall $7.81 - 3.92 = 3.89$ yards to the right of the target.

In aiming for the second shot suppose the wind be at AW_1 . The correct allowance is then 3.92 yards to the right. After aiming and before firing let the wind shift to AW_2 , making an angle of 10° on the other side. The gun being aimed 3.92 yards to the right, and the changed wind deviating the shot still other 7.81 yards, the shot will strike 11.73 yards to the right of T .

On the other hand, if the wind's general, or average, direction be nearly perpendicular to the plane of fire, small changes in δ cause scarcely any change in the deviation. Suppose $\delta = 80^\circ$ and suddenly becomes 85° , the effect upon deviation, for the same wind as before, is only 0.5 of a yard. In the case just cited above, the same angular change caused a deviation of almost 4 yards. A change of the wind from 85° to 90° would give a difference of about 0.17 of a yard.

We see from this that as the wind blows more nearly perpendicularly to the plane of fire, the less effect will small angular changes have upon the deviation. Small changes near the perpendicular may be neglected, but when the wind is nearly parallel to the plane of fire these changes are of great importance.

Before concluding this paper a brief comparison of the coefficient, 1.81, with the coefficient determined at Fort Monroe, may be interesting. Since the conditions are not the same we cannot expect the same results, but there exists a certain agreement between them. Inasmuch as the initial and remaining velocities for these experiments are not given, our comparison will not have the weight it should have. One marked difference in the circumstances of fire is the time of flight. In the experiment it was 10.83 seconds; in the computations resulting in the coefficient 1.81 it is 8.125 seconds. In the former the density of the air is represented by 0.937, in the latter by "unity." These, with other less important differences in the two cases, render exact agreement impossible.

From the range, 3103 yards, and the mean elevation of $8^{\circ} 43'$ the initial velocity was found by trial to be 1370 feet, and the remaining velocity at that range to be 741.1 feet. From these velocities the time of flight was computed and found to be 9.898 seconds. Having obtained these from the data given in *Ordnance Note* 191, we may make an approximate comparison between the two examples.

We find, by following the approximate method illustrated above, that the mean of the deviating pressures at the extremities of the trajectory is 16.39 pounds. This force considered constant and acting on the projectile for 9.898 seconds gives a deviation of 18.99 yards.

For the observed time of flight this force gives 22.73 yards. When the initial velocity is 1706 feet, we find for same range and atmospheric conditions that the mean of the extreme deviating forces is 20.89 pounds. These pounds acting during 8.41 seconds as a constant force give a deviation of 17.05 yards. The true deviation for these atmospheric conditions would be 18.117 yards.

Now, since the approximate method gives about 1 yard less than the true one, we may reasonably infer that in the other case 18.99 is also a yard less than the correct value; therefore, 20 yards is not far from the total deviation in a ten-mile wind, nor 2 yards far from the correct coefficient.

So far as this comparison goes it confirms the preceding theory, but it is too indefinite to be of special value.

The most important facts connected with lateral deviation being thus brought out, without extending the investigation farther, let us pass to the most important conclusions.

1. The lateral deviation of a projectile under the action of a side wind is not the result of wind-pressure, but of a kind of drifting motion, caused by a developed oblique resultant resistance.

2. Deviation is a ballistic problem and must be solved as any problem in exterior ballistics.

3. Deviation is a function of the remaining velocity of the projectile; any circumstances affecting this velocity changes the deviation.

4. Deviation is a function of the time of flight, and increases rapidly as the time increases.

5. For moderate winds, deviation varies directly with the wind's velocity; and in general, when the tangent of φ may be substituted for the *sine* of φ without appreciable error, this law obtains.

6. In high winds, independent of any change in time of flight, deviation is greater for winds that retard than for those which accelerate; and in the former, deviation increases more rapidly, and in the latter less rapidly than the wind's velocity.

7. When the wind's direction falls near the plane of fire, changes in δ are of greatest importance, and cause irregular results.

8. Other things being equal, deviation varies inversely as the weight of the projectile.

9. Deviation varies almost exactly with retardation of the projectile's velocity.

10. Deviating components of the wind's velocity increase the resistance and time of flight. This results from the projectile being forced to follow a horizontal curve, which is a path of greater resistance than a plane curve. Gravity affects the projectile's flight in the same way, but in a greater degree, giving the projectile a curved instead of a straight path. As, on account of gravity, we must aim above the object, so, on account of the wind, we must aim to windward to strike it.

For simplicity the spherical projectile has been taken to illustrate this subject, but the deduced results apply to all kinds of projectiles; indeed, to all bodies moving in a fluid itself in motion.

The discussion in this paper is occupied almost exclusively with lateral deviation.

The effect of the wind upon the projectile's velocity and range is also involved in this investigation. The longitudinal effect is not less interesting or important than the lateral, and is reserved for future development.

The theory accounts for all the well-established facts connected with the wind's influence upon a moving projectile, and predicts others which will probably be confirmed by careful experiment.

It is to be hoped that the needful experiments will soon be made, for whatever may be the promise of a theory, a satisfactory confirmation of its conclusions can only be reached by trial. We cannot overestimate the beneficial and economic results that would follow an early settlement of this subject.

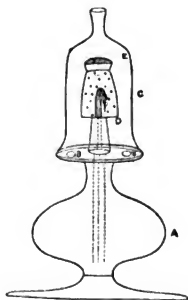
ABSTRACTS.

[ANALYTICAL CHEMISTRY, BY E. WALLER.]

New Appliance for Detection of Hydrocarbons and other Combustible Gases when in Admixture with the Atmosphere.

This peculiar form of gas-testing apparatus is intended chiefly for the detection of suspected escapes of coal-gas when in confined spaces, such, for instance, as private houses, laboratories, etc.

If asbestos (for convenience sake in the form of yarn) be introduced into a solution of platinic chloride, and, after drying, ignited in a closed crucible, the substance, as is well known, has conferred upon it the property of condensing gases upon its surface, due to the impregnation of what is known as platinum black. This method of rendering asbestos sensitive is, however, attended with several inconveniences, both on account of the disengagement of acid during ignition, thus rendering the texture rotten, and at the same time retarding surface-action by the formation of magnesium salts. The writer has substituted with advantage for the chloride that of platinic oxalate, and by so doing has obtained a modified action of peculiar sensitiveness. This compound is readily procured by saturating asbestos yarn of finest quality with a strong solution of platinic oxalate, obtained by dissolving the hydrate of that metal in oxalic acid and, after drying, igniting the same in a porcelain crucible. If a sample of so-prepared asbestos be now introduced into a mixture of hydrogen and oxygen gases, combination at once takes



place, accompanied by the usual phenomenon; but if the said mixture be now replaced by one of coal-gas and oxygen, no action results. Withdraw now the sensitive wick and heat to 80° F. and replace the same in the mixture, the wick is quickly raised to incandescence, and continues as long as the slightest mixture of gas remains; so sensitive, in fact, is the reaction that 0.5 per cent., by volume of coal-gas or other

hydrocarbons, when in admixture with the atmosphere, is at once readily detected.

The figure on page 59, representing a section of the apparatus when in use, will perhaps serve to more clearly demonstrate the same, A serving as the basis or reservoir of the lamp, and containing petroleum spirit, which is employed as a fuel for the same, and surmounted by a gallery running round the upper part and pierced with two apertures at B B, intended to collect the air desired when applying the chimney, C. In using the apparatus the wick, consisting of platinized asbestos, is first inserted in its holder and a light applied to the same. The flame caused by the combustion of the petroleum spirit may be now conveniently extinguished, leaving the uppermost part of the wick red-hot, which continues to glow while any petroleum spirit remains in the reservoir. While the wick is still glowing there is placed over it the copper thimble, D, which is perforated with numerous small holes, and containing a further coil of platinized asbestos, E, in close proximity.

The reaction may thus be readily explained: The heated asbestos, fed by the petroleum spirit, naturally produces sufficient heat to maintain the secondary coil at E to a temperature required for producing effects when in contact with hydrocarbons. If the so-prepared lamp be now introduced into a room where an explosive atmosphere is prevalent, the glass chimney at once samples the atmosphere by causing an upward draught, the which, passing over the heated coil immediately raises the same to incandescence.—H. N. Warren, in *Chemical News*, June 13, 1890.

Impurity in Hydrodisodic Phosphate. Schlagdenhauffen (*J. Pharm.* [5] xxi., 99). A soluble magnesium phosphate has been found as impurity. The solution of the salt mixed with NH_4Cl and NH_4OH should be allowed to stand 24 hours before using.

Impurity in Nitric Acid. Huxley (*Chem. News*, lxi., 289). Sulphates were found to be present, derived from the bottles in which the acid was supplied. In the particular case cited, the greenish glass bottles contaminated the acid, whereas the bluish glass bottles did not.

Purification of Sulphuric Acid for use in the Kjeldahl process. Moritz. (*J. S. C. I.*, ix., 443.) The method of digestion with a small amount of potassium nitrite has been adversely criticized by Prof. Lunge. Experiments are quoted to show that whatever compounds may be formed, acid treated in this manner introduces no error when applied in the Kjeldahl process.

Iodometric Acidimetry and Alkalimetry. Groeger (*Berichte*, xxiii. 1401). The reaction involved is: $\text{KIO}_3 + 5\text{KI} + 3\text{H}_2\text{SO}_4 = 3\text{K}_2\text{SO}_4 + 3\text{H}_2\text{O} + \text{I}_2$. The solutions used are: Tenth normal thio-sulphate; tenth normal sulphuric acid, and a neutral solution of $\text{KI} + \text{KIO}_3$. On adding a known amount of the sulphuric acid (sufficient to make the solution decidedly acid) the excess may be titrated by the use of the iodide-iodate solution and the standard thio-sulphate solution. Acids may be titrated directly.

Aluminum in Commercial Aluminum. Klemp (*Fres. Zts. Anal. Chem.*, xxix., 388). About 1 g. of the finely divided sample, is treated with strong potash solution (35 gms. in 100 c.c.), a little water is added and then some vaseline to prevent frothing. The evolved hydrogen is burned to water in a Fresenius apparatus, and the water absorbed in concentrated H_2SO_4 and weighed. The operation can be finished in about 45 minutes.

Aluminum in Iron and Steel. Phillips (*Chem. News*, lxi., 313). Dissolve 10 gms. in 50 c.c. HCl with 30 c.c. HNO_3 . When dissolved, add 5 c.c. Na_2HPO_4 (saturated solution) and 100 c.c. water. Neutralize free acid with NH_4OH , add dilute HCl until the solution is clear, then *not over 2 c.c.* strong HCl . Follow this with 50 c.c. saturated solution of "hypo," cover and boil one hour. Filter, wash well with hot water, rinse the residue from the filter into the beaker in which it was boiled, and dissolve in 100 c.c. of 10 per cent. HCl . Boil and filter off sulphur. Evaporate filtrate to 5 c.c., rinse into platinum dish, neutralize with pure NaOH (made from sodium) and add 2 gms. NaOH in excess. Boil half an hour. Dilute and filter off iron, wash and acidify mixed filtrate and washings with HCl , precipitate AlPO_4 , etc., with ammonia. Redissolve in HCl , evaporate to dryness for SiO_2 , take up with dilute HCl , filter, add a 5 c.c. ammonia phosphate NH_4OH and a little ammonia acetate. Boil 30 minutes, filter and wash with diluted ammonia phosphate, ignite and weigh AlPO_4 which contains 22.358 per cent Al . The process can be carried through in six hours. In effect it is a modification of that of Stead (*vide Quarterly*, xi., 273).

Rapid Determination of Manganese in slags, ores, etc. Myhlerz (*Jour. Analyt. Chem.*, iv., 267). Fuse 0.5 gm. after thorough mixing with 5 gms. of a mixture of 3 parts Na_2CO_3 and 1 part KNO_3 . Maintain the temperature only at such a point as suffices to effect quiet fusion. Cool, pour on boiling water to disintegrate the mass, and then add 3 c.c. alcohol to convert all the Mn to the form of MnO_2 . Filter and wash to remove nitrates. Rinse the precipitate back into the casserole in which the water treatment was made, (in which should remain the crucible and cover with any adhering MnO_2). Then add 100 c.c. of a standard FeSO_4 solution, stir until completely dissolved, and titrate the excess of ferrous salt remaining with dichromate. The amount of dichromate solution rendered unnecessary is the measure of the MnO_2 (or Mn) present.

Volumetric for Manganese. Vortmann (*Ber.*, xxiii., 280). Manganous salt in alkaline solution are converted by iodine solution into MnO_2 . Without any addition 1.84 to 1.86 atoms I instead of exactly 2. effect the change completely; however, on adding an Al_2O_3 or Fe_2O_3 salt, exactly 2 atoms of I are used. Hence the author adds 2 to 3 times as much potash alum, as there is Mn salt present, then a known amount of tenth normal iodine solution, and pure soda lye, heats on the water-bath for 5 to 10 minutes, cools and dilutes to a known volume, filters an aliquot portion through a dry filter, acidifies and titrates with hypo. The method is unsatisfactory in presence of ammonium salts.

Zinc in Presence of Iron and Manganese. Riban (*C. Rend.*, cx., 1196). (*vide* previous abstract *Quarterly*). Dilute until the solution contains at most 0.1 gm. Zn per 100 c.c. Add Na_2CO_3 solution until there is a slight permanent precipitate, which should be redissolved by a few drops of dilute HCl. Pass H_2S in the cold, then add a large excess of $\text{Na}_2\text{S}_2\text{O}_3$ solution, and continue passing H_2S . The Zn S is completely precipitated, practically free from Fe and Mn. Allow to stand five or six hours, and then wash by decantation with hot water containing H_2S . Pb, if present, should be previously separated.

Zinc in Iron Ores. Platz (*Stahl u. Eisen*, ix., 494). After dissolving in HCl, and adding a little HNO_3 , hydrosulphuric acid is passed into the warm solution. Any sulphides of copper, etc., which may form are filtered off. If, however, only S has separated, filtration is omitted. To the solution, saturated with H_2S , acetic acid and ammonium acetate are added, and then ammonia, little by little, (from a burette) until the precipitate remains gray, after vigorous stirring. Then add dilute HCl, drop by drop, until it becomes white, and then carefully dilute ammonia until it has a very slight grayish tinge. The precipitate is then practically pure.

Zinc in its Ores. Coda (*Fres. Zts.*, xxix., 266). The method depends upon the fact that ferric iron, etc., can be separated completely from zinc in one operation, by precipitating with ammonia in presence of ammonium sulphate and a little carbonate. Dissolve 2.5 gms. ore in 15 to 20 c.c. aqua regia—evaporate to dryness, add 15 to 20 c.c. H_2SO_4 and heat to fumes,—dilute, precipitate by H_2S if necessary, bring the iron to the ferric form, neutralize with ammonia, then add 40 c.c. of ammonia containing one-fourth ammonium carbonate. Agitate, cool, dilute to 500 c.c., filter and take out two or three lots of 100 c.c. each. (0.5 gm. each.) Dilute each lot to 250 c.c., and titrate with Na_2S .

Volumetric for Zinc. Blum (*Fres. Zts.*, xxix., 271), finds that in ferrocyanide titration, whether in acid or ammoniacal solution, manganese if present, will interfere by forming ferrocyanide.

Reduction of Arsenic Acid. Gooch and Browning (*Am. Journ. Sci.*, July, 1890). To the arseniate in solution, add KI in excess, and 10 c.c. H_2SO_4 (1:1). Dilute to 100 c.c. and boil in a flask (with trap hung in the neck, until the volume is reduced to 40 c.c. Add cautiously SO_2 solution until the iodine color is just bleached out, and then immediately dilute with cold water, neutralize with K_2CO_3 finishing neutralization with KHCO_3 . Cool and titrate as usual with iodine solution and starch. The reaction for the reduction is found to be $\text{H}_3\text{AsO}_4 + 2\text{HI} = \text{H}_3\text{AsO}_3 + \text{H}_2\text{O} + \text{I}_2$, provided the above conditions are maintained.

Determination of Lead. Boeuf (*Bull. Soc. Chim.* [3] iii., 852). Lead phosphomolybdate contains 54.802 per cent. Pb, and separates readily from a solution which is neutral or slightly acid with acetic acid. The precipitation should be effected in a boiling solution, the solution of phosphomolybdic acid being slowly added until the yellow tint of

the solution indicates an excess. It is then allowed to stand a few minutes when the precipitate subsides rapidly. It is then filtered on a weighed filter, washed, dried at 90 to 100° and weighed. The precipitate may be rinsed into a flask, treated with sulphuric acid and zinc and titrated as in the case of the rapid determination of phosphorus in irons. Iron, if present, should be removed by previously adding NaOH in excess, filtering and rendering the filtrate acid with acetic acid before precipitating Cu, NH₄ and K may contaminate the precipitate, but are readily removed by washing with NH₄OH. Zinc and arsenic interfere. The method of preventing their interference has not yet been devised.

Volumetric for Silver. Vitali (*Chem. Ztg.*, xiv., 154). Tenth normal potassium ferrocyanide is used, *i. e.* containing 9.2 gms. of the salt dried at 100° to 105° per litre.

Electrolytic Separations. Smith and Frankel (*Am. Chem. Jour.* xii., 428). Hg was separated from Pd in KCy solution, when an excess of KCy was used.

Hg, Cd and Ag were also found to be separable from As in KCy solution, provided the arsenic form only was present. Cu was separable from As provided a strong current was used, and no excess of KCy. If NH₄OH was present the deposit was spongy.

Hg, Ag and Cd were also separable from W or from Mo in KCy solution. In the case of Cd from W it was noted that unless a weak current was used, the deposit was spongy.

Bi was separated from Cu by adding alkaline citrate and alkali, in sufficient quantity to keep the solution clear on addition of KCy, which was then added in slight excess and the solution electrolyzed.

The strength of the current used in these experiments, except in the case of Cu from As, was under 1 c.c. O H gas per minute.

Electrolytic Separation of Arsenic and Copper. McCay (*Chem. Ztg.*, xiv., 509). The solution is rendered slightly alkaline with ammonia, and a current from four to six Meidinger cells passed through it for six hours or more, when the copper entirely free from arsenic is found to be completely precipitated.

Oxidizing Sulphides by Electricity. E. F. Smith (*Berichte*, xxiii., 2276). By fusing caustic potash together with the sulphide in a nickel crucible, and making the crucible the anode in an electric circuit, the sulphur in most mineral sulphides was readily oxidized in about 20 minutes by a current of one ampere. The melt after cooling was extracted with water filtered, acidified, and Ba SO₄ precipitated as usual. Pyrite was the only sulphide which resisted these conditions, half of the sulphur only oxidizing, but by adding CuO, and using a current of 4 amperes all the sulphur was oxidized in 20 minutes.

Nitric Acid Determined by Electrolysis. Vortmann (*Ber.* xxiii., 2798) finds that the nitrogen may be readily converted into ammonia by electrolyzing a solution of nitrate acidified with H₂SO₄.

The change is much more rapid if a metallic salt decomposable by the

current is introduced. Copper sulphate is preferable. The amount must be proportional to the amount of nitrate present, *e.g.* With a certain amount of KNO_3 , if we add half its weight of crystallized CuSO_4 , the reaction is complete when all the Cu has been precipitated by a current of 1 to 2 c.c. oxyhydrogen gas per minute. The solution may then be titrated acidimetrically, the degree of acidification and amount of CuSO_4 added being known. Or the positive electrode may be plated with copper, and the current reversed as often as may be necessary to transfer the copper from one pole to the other.

Phosphorus in Irons and Ores. Jones (*Am. Inst. Min. Eng., Washington Meeting*, Feb., 1890) summarizes the method which can be used so as to give results in an hour or less, provided that As or Ti are not present.

For Pig Iron or Steel.

- I. Dissolve in 60 c.c. HNO_3 (Gr. 1.135).
- II. Boil one minute (after action ceases).
- III. Add 5 c.c. $\text{K}_2\text{Mn}_2\text{O}_8$ (or until MnO_2 precipitates).
- IV. Dissolve the MnO_2 with FeSO_4 (free from P_2O_5).
- V. Filter into a flask (500 c.c. capacity).
- VI. Add 10 c.c. NH_4OH (Gr. 0.90) or nearly neutralize.
- VII. Test for oxidation (III. and IV.). This is done while solution is heating.
- VIII. Add 75 c.c. Molybdate solution at 85°C . and shake vigorously for five minutes.
- IX. Filter and wash with $(\text{NH}_4)_2\text{SO}_4$ solution [$(\text{NH}_4)_2\text{SO}_4$ 25 gms. H_2SO_4 conc. 50 c.c. H_2O , 2500 c.c.].
- X. Dissolve in NH_4OH (Gr. 0.96). Observe precautions.
- XI. Add 30 to 50 c.c. sulphuric acid (1:2 water) and filter through reductor, observing precautions mentioned. (*Trans.*, xvii., 414.)
- XII. Titrate.

For Iron Ores.

- I. Dissolve in HCl (Gr. 1.12).
- II. Filter, evaporate filtrate with HNO_3 (Gr. 1.20).
- III. Fuse residue with excess Na_2CO_3 , dissolve in dil. H_2SO_4 (1:2) combine solutions when filtrate with HNO_3 is ready. Proceed as above from III. to end.

Phosphoric Acid in Presence of Silica. Preis (*Jour. Chem. Soc.*, lviii., 825) finds that phosphoric acid may be separated as phospho-molybdate in presence of considerable quantities of silica, if the precipitate is washed with pure cold water. The washings have a tendency to turbidity at the end.

Foreign Phosphates in Thomas-slag. Blum (*Fres. Zts. Anal. Chem.*, xxix., 408). Fresh Thomas-slugs contain no carbonates. After grinding and long exposure to air they contain not over 2.5 per cent. CO_2 . The presence of any notable quantity of CO_2 is therefore proof of this form of adulteration.

Test Paper for Chlorides. Hoogoliet (*Polyt. Notizblatt.*, xlv., No. 18). Precipitate AgNO_3 with K_2CrO_4 , dissolve the precipitate in ammonia, saturate filter paper with the solution, dry it. While yet moist dip into dilute nitric acid, which precipitates finely divided Ag_2CrO_4 on the paper. Water containing 0.03 of NaCl decolorizes this paper in a few seconds.

Iodine Determinations. Stortenbeker (*Frs. Zts.*, xxix., 272). In presence of Cl , iodine chloride may be formed, and in a known amount of this the I determined by decomposition with KI and titration with hypo. The reaction with ferric salts, distilling and titrating (Duflos method), may also be used, but it depends upon the ratio between ferrous and ferric salt in the solution, as well as the degree of dilution as to whether all of the I is expelled. By concentrating the acidulated solution the equilibrium between the iodide, ferrous and ferric salt is gradually destroyed, and eventually all of the iodine may be expelled.

Iodide in Presence of Chloride. (Johnstone, *C.W.*, lxii., 153). A good qualitative test is the addition of a drop of AgNO_3 in strong ammonia. The AgI is so much more insoluble in the ammonia that the test is tolerably delicate.

Carbon in Iron and Steel. Pettersson and Smith (*Ber.*, xxiii., 1401). 0.4 to 0.8 gm. of the iron preferably in one piece, is decomposed in fusing KHSO_4 . This requires 5 to 12 minutes (longer if the iron is in the state of borings). The products are FeSO_4 , SO_2 and CO_2 . The FeSO_4 with the flux and graphitic carbon remains in the crucible. By passing a current of air (free from CO_2) the SO_2 and CO_2 may be caught in a measured quantity of sodium or barium hydrate solution.

A slight excess of permanganate will serve to oxidize the sulphite, leaving the carbonate to be determined by some convenient method. The authors prefer an apparatus of their own devising, in which the CO_2 is expelled from the solution after acidifying by boiling under reduced pressure, the gas being finally measured (*Ber.*, xxiii., 1402).

The melt is cooled, dissolved in dilute HCl , the graphite, etc., filtered off through asbestos, weighed, ignited in nitrous fumes, and weighed again, thus determining the graphite by loss.

Nitrogen in Chili Saltpetre. Forster (*Chem. Ztg.*, xiv., 509). By evaporating a weighed quantity two or three times with HCl , finally igniting gently, and weighing, the nitrate is converted to chloride. The loss of weight multiplied by 0.52828 gives the nitrogen present in the nitrate. The process is inapplicable if magnesium salts are present, on account of the decomposability of the MgCl_2 by evaporation.

Hardness Test for Water. Neugebauer (*Fres. Zts. Anal. Chem.*, xxix., 399). The author prepares a soap solution by lead plaster and K_2CO_3 and standardizes with a solution made of 8 parts 12°CaSO_4 solution and 2 parts 12°Mg SO_4 solution. Waters to be tested must be diluted until they will show a hardness not over 12° . Since the water destroys some of the soap, 100 c.c. taking 0.6 c.c. soap, 1° taking 1.7 c.c. soap, and so on, a burette especially graduated for the purpose is used, from which the degrees of hardness can be at once read off.

Water Contaminated by Gas Works was found by Dickmann (*Fres. Zts. Anal. Chem.*, xxix., 398) to contain diphenylamin, the residue from 500 c.c. giving a well-defined blue color, by addition of sulphuric acid. (Nitrates being present the addition of HNO_3 was unnecessary.) The water gave negative or uncertain reaction for CO, sulphocyanates or other cyanogen compounds.

MINERALOGY, BY A. J. MOSES.

ACHTARAGDITE.

Possibly pseudomorphous after boracite.—*Neues Jahrb. Min. Ref.*, 1890, ii., 19.

AKERMANITE, *Vogt*.

A tetragonal lime magnesia silicate near melilite, not found in nature but obtained in experiments upon the formation of minerals by fusion.—*Amer. Journ. Sci. Abs.*, xl., 336.

AMARANTITE.

Crystallization proved triclinic, slender prismatic doubly terminated crystals of brownish to amaranth-red having been determined.

Specimens were from Mina de la Compania, Sierra Gorda, Tocopilla, Chili. Associated is a fine fibrous orange mineral, probably Sideronitrite.—*Amer. Journ. Sci.*, xl, 199.

ARSENIOPLEITE, *L. J. Igelström*, $2R''_3\text{As}_2\text{O}_8 \cdot R'''_2\text{As}_2\text{O}_8 \cdot 3R'(\text{OH})_2$.

Occurs in kernels and masses in dolomite. $\text{H.} = 3-4$; color, cherry-red to brownish-red; streak, yellow to brown. Fracture conchoidal.

Before the blowpipe melts to black, non-magnetic globule with strong odor of arsenic, yields water in closed tube. Easily dissolved to yellow solution without residue in dilute HCl and HNO_3 .

Analysis shows: As_2O_5 , 44.98; MnO, 21.25; Mn_2O_3 , 7.80; Fe_2O_3 , 3.68; PbO, 4.48; CaO, 8.11; MgO, 3.16; H_2O , 4.54.

Found at Sjö mine, Örebro, Sweden, associated with foliated rhodinite, dolomite and barytic feldspar (Albite).—*Zeit. F. Kryst.*, xviii., 313.

ASMANITE.

Mallard claims its essential identity with tridymite.—*Bull. Soc. Franc. Min.*, xiii., 170.

BOHIERRITE is $\text{Mg}_3\text{P}_2\text{O}_8 + 8\text{H}_2\text{O}$.

CARPHOSIDERITE.

Occurs at Saint Leger, Saone et Loire, in cavernous quartz as minute hexagonal prisms, which are transparent and golden yellow. Also found, both at above locality and at Laurium, as micaceous or earthy masses consisting of crystalline lamellæ.—*Bull. Soc. Franc. Min.*, xiii., 8.

CERVANTITE.

The yellow incrustations upon stibnite from Felsobanya, Hungary; Estramadura, Spain; and Siegen, Prussia, and a similar crust upon botryoidal orpiment from Felsobanya, prove to be zinc sulphide instead of cervantite as supposed.—*Min. Mag.*, vol. ix., p. 9.

CIPLYTE, *J. Ortlie*, $4\text{CaO}, 2\text{P}_2\text{O}_5, \text{SiO}_2$.

Found at Ciply and elsewhere in Belgium in the chalk associated with phosphorite. Analysis was made upon impure material.—*Bull. Soc. Franc. Min.*, xiii., 160.

CONNELLITE, *Dana*, $\text{Cu}_{15}(\text{Cl}, \text{OH})_4\text{SO}_{16} + 15\text{H}_2\text{O}$. Hexagonal.

Recent re-examination by S. L. Penfield.

Occurs in slender prismatic crystals terminated by pyramid of opposite order. $\text{H} = 3$. $\text{G} = 3.364$; color, beautiful dark blue; streak, pale greenish-blue.

Before the blowpipe, fuses at 2 to bright globule coloring flame green. Soluble in dilute acids.

Found at Camborne, Cornwall.—*Amer. Journ. Sci.*, xl., 82.

COSSAITE,*

Occurs in dense lamellar masses. $\text{H} = 2.5$. $\text{G} = 3.075$; lustre, pearly; color, apple-green. Optically, biaxial. Powder somewhat greasy.

Before the blowpipe, melts to a white opaque mass. Insoluble in hydrochloric acid.

Analysis shows: SiO_2 , 46.49; Al_2O_3 , 40.68; Fe_2O_3 , 2.68; Na_2O , 4.75; K_2O , 1.34; H_2O , 4.57; or very near the Cossaite of Borgofranco near Ivrea and of Colle Blaisier.

Found at Bousson.—*Zeit. f. Kryst.*, xviii., 77.

COUSERANITE.

M. Ch. L. Frossard suggests that the name couseranite, now only a synonym of dipyre, be used as the name of all altered dipyre.—*Bull. Soc. Franc. Min.*, xiii., 187.

CRISTOBALTITE (Christobaltite), *v. Rath*, SiO_2 . Orthorhombic.

Occurs at Cerro San Cristobal in small white crystals, apparently regular octahedra, formed by grouping of three quadratic crystals. The crystals are almost opaque but become translucent in a liquid. $\text{G} = 2.34$; lustre, dull. Double refraction destroyed at 175° while that of tridymite disappears at 130° .

Before the blowpipe is not altered. Easily soluble in alkaline solutions.—*Bull. Soc. Franc. Min.*, xiii., 172.

* Referred by Cossa to Mica, and by Gastaldi to Oncosine (v. Pinite).

CROCIDOLITE.

Study of optical properties and notice of localities. Conclusion that it is optically distinct from glaucophane.—*Lacroix, B. S. F. M.*, xiii., 9.

CRYPTOLITE is monazite according to Mallard.—*B. S. F. M.*, 1887, x., 236.

DURDENITE, *E. S. Dana and H. L. Wells*, $Fe_3(TeO_3)_3 + 4H_2O$.

Found at El Plomo mine, Tegucigalpa, Honduras, in points and veins scattered through quartzose conglomerate. $H. = 2 - 2.5$; color, greenish-yellow.—*Amer. Journ. Sci.*, xl., 79.

ERYTHRITE.

As crystalline groups of an impure rose color, coating pyrite, calcite, byssolite, etc., at French Creek, Pa.—*Amer. Journ. Sci.*, xl., 115.

FAYALITE.

In the hollow spherulites of the obsidian from Lipari are found crystalline kernels with radial structure. The centre of a kernel is dense and gray, but the outer portion is a mass of radiating acicular crystals of alkali feldspar and many small white crystalline pellets of tridymite. Similar crystals coat the inside of the shell.

Associated with the tridymite are occasional thin minute tablets of fayalite, sometimes clear and transparent, sometimes altered and opaque.—*Amer. Journ. Sci.*, xl., 75.

FERRONATRITE.

Found at Mina de la Compania, Sierra Gorda, Tocopilla, Chili, in cleavable masses, probably hexagonal. Color white to grayish white. $H. = 2.5$ G. = 2.547 — 2.578. Optically uniaxial.—*Amer. Journ. Sci.*, xl., 202.

FERROSTIBIAN, *L. J. Igelström*, $R_{10}Sb_2O_{12} \cdot 10R(OH)_2$ Monoclinic.

Occurs in acute crystals showing $\infty P \infty, \infty \bar{P} \infty$, OP. $H = 4$. Feebly magnetic. Lustre, submetallic. Color black or grayish-black. Streak, brown. Opaque. Before the blowpipe, melts with difficulty to a black magnetic globule. Easily soluble in dilute hydrochloric acid to yellow solution. Analysis shows: Sb_2O_3 , 14.80; FeO, 22.60; MnO, 46.97; H_2O , 10.34; Mg_2CO_3 , $CaCO_3$, 2.14; Insol. 2.24 = 99.09.

Found at Sjö mines, Orebro, Sweden, in rhodonite.—*Neues. Jahrb. Min. Ref.*, 1890, II., 221.

GARNET (Titaniferous).

Brown massive garnet from Jones Mine, Green River, Henderson Co., N. C. contained 4.58 per cent. TiO_2 .—*Amer. Journ. Sci.*, xl., 117.

GIBBSITE of White Horse Station, Chester Co., Pa. proves to be a hydrous aluminium phosphate of unknown constitution.—*Amer. Journ. Sci.*, xl., 206.

GORDAITE, *Frenzel*, $3\text{Na}_2\text{SO}_4 \cdot \text{Fe}_2\text{S}_2\text{O}_8 + 3\text{H}_2\text{O}$.

Occurs in indistinct crystals, perhaps triclinic. Also found in small foliated masses with fibrous structure. $\text{H.} = 2.5 - 3$. $\text{G.} = 2.61$. Lustre, vitreous; colorless to white or light gray. Analysis shows: SO_3 , 50.85; Fe_2O_3 , 19.42; Na_2O , 22.36; H_2O , 7.33. Found in Chili, associated with Sideronatrite.—*Amer. Journ. Sci. Abs.*, xl., 259.

GRAPHITE.

Graphite of Ceylon is believed by J. Walther to have been introduced in the veins in form of gaseous hydrocarbon rich in carbon. Occurrence in Ceylon and theories of formation are discussed by F. Sandberger. *Neues Jahrb. f. Min.*, 1887, v. 2, p. 12, and by J. Walther.—*Zeit. d. deutsch. geol. Ges.*, xli., p. 359.

HAMBERGITE, *Brögger*, $\text{Be}_2\text{BO}_3\text{OH}$. *Orthorhombic*.

A single crystal, 3.5 c.m. in length by 1.5 c.m. in thickness and width. Cleavage parallel to $\infty \bar{P} \infty$. $\text{H.} = 7.5$; $\text{G.} = 2.347$. Lustre, strongly vitreous. Color, grayish-white. Transparent to translucent. In appearance resembles boracite. Thin sections show under the microscope inclusions of magnetite.

Before the blowpipe, decrepitates slowly, but is infusible. Insoluble in acids. Mean of three analyses shows, BeO , 53.25; B_2O_3 , 36.72; H_2O , 10.03.

Found near Helgeraen, Norway, in feldspar. Named after the discoverer, A. Hamberg.—*Zeit. f. Kryst.*, xvi., 65.

HIORTDAHLITE, *Brögger*. *Triclinic*.

A mineral resembling wöhlerite occurring in small thin crystals usually twinned. $\text{G.} = 3.251$. Lustre, vitreous on a crystal face but adamantine on fracture. Color, various shades of yellow, rarely yellowish-brown.

Before the blowpipe, melts easily to a yellowish white-enamel. Gelatinizes in acids.

Analysis shows: SiO_2 , 31.60; TiO_2 , 1.50; ZrO_2 , 21.48; CaO , 32.53; Na_2O , 6.53; F , 5.83; Fe_2O_3 , 0.34; FeO , 0.94; MnO , 0.96; MgO , 0.10; H_2O , 0.58.

Found at Island of Mittel-Arö, Langesundfjord, Norway, in a white feldspar, with a dark mica, some elæolite and often fluorite. Named after Prof. Th. Hiortdahl, of Christiania.—*Zeit. f. Kryst.*, xvi., 367.

JOHNSTRUPITE, *Brögger*. *Monoclinic*.

A brownish-green mineral found in the neighborhood of Barkevik, Norway, and resembling in composition and form the mosandrite of Stöko and Laven, and considered homeomorphous with it through a distinct species. $\text{G.} = 3.29$. Lustre, vitreous on crystal face, resinous to adamantine on fracture. Named after Prof. Fr. Johnstrup, of Copenhagen.—*Zeit. f. Kryst.*, xvi., 74.

KALIBORITE, *W. Feit*. Occurs massive with granular structure. $\text{G.} = 2.05$. Analysis shows: B_2O_3 , 57.46; MgO , 12.06; H_2O , 24.00. Found

near Aschersleben, Prussia, associated with pinnoite.—*Amer. Journ. Sci.*, xl., 336.

KARYOCERITE, *Brögger*, $H_4(Zr, Th, Ce)_2O_4 F_4$. *Rhombohedral*.

Occurs in tabular crystals sometimes intermixed with a clear yellow amorphous compound. $G. = 4.295$. Color, nut-brown. Fracture conchoidal.

Before the blowpipe, becomes transparent but does not fuse.

Found at Stöko, Norway, with ægirite, catapleite, astrophyllite, feldspar and elæolite.—*Zeit. f. Kryst.*, xvi., 478.

LETTESOMITE.

One specimen from Copper Mt. Mine, Arizona, in incrustations on siliceous gangue. Color deep sky blue to azure blue; lustre, silky; thin fibres and small radiated tufts.

One specimen from American Eagle Mine, Tintic, Utah, is a velvet-like azure blue coating upon a bluish-green clay-like mineral.—*Amer. Journ. Sci.*, xl., 118.

LEVERRIERITE, *P. Termier*. *Orthorhombic*.

Occurs in vermicular forms usually called bacillarites; cleavage basal. $G. = 2.3$; colorless to brown, pleochroic.

Analysis shows: SiO_2 , 49.30; Al_2O_3 , 22.60; Fe_2O_3 , 0.34; MnO , 0.40; CaO , 6.80; MgO , 0.66; K_2O , 1.36, on heating, 17.90.

Found at Quartier-Gaillard near St. Etienne, in sandstone, clay and coal, sometimes associated with small zircons and apatites.

Named after M. LeVerrier.—*Neues Jahrb. Min. Ref.*, 1890, ii., 37. See also *Ann. des Mines*, v. 17, p. 372.

LUSSATITE, *Mallard*. SiO_2 .

A siliceous coating upon quartz consisting of microscopic fibres perpendicular to the surface of the quartz. $G. = 2.04$; color, somewhat milky; doubly refracting in direction of length, optically positive.

Found in the bitumen of Lussat and other localities near Pont du Château.

Similar fibres are found in the yellow stratified opal from the Faroe Islands.—*Bull. Soc. Franc. Min.*, xiii., 63.

MELANOPHLOGITE.

Mallard notices that the clear cubical crystals are composed of fibres radiating from centre to sides, which are optically negative, and possess slight double refraction that disappears at about 400° . $G. = 2.04$.

Frequently the cubes contain strongly doubly refracting particles optically positive, $G. = 2.65$, which become white and opaque when the fibrous melanophlogite blackens under the action of heat. Evidently these are quartz.

In one specimen with yellowish crystals the material was almost entirely quartz.—*Bull. Soc. Franc. Min.*, xiii., 180.

METACINNABARITE.

A specimen found in the quicksilver mine at New Almaden, California, carries finely-developed crystals which are rhombohedral and hemimorphic. The Knoxville metacinnabarite has been described as hemihedral isometric, but the crystals have been very indefinite.—*Journ. Sci.*, xl., 201.

NEOTESITE, *Igleström*, $R_2SiO_4 + H_2O$.

Occurs massive cleavable, resembling red orthoclase. $H. = 5-5.5$. Lustre, vitreous; color, brownish-red.

Before the blowpipe melts easily to black globule, yields much water in closed tube. Soluble in hydrochloric and sulphuric acids with separation of flocculent silica. After heating it is insoluble.

Analysis shows: SiO_2 , 29.50; MnO , 40.60; MgO , 20.05; H_2O , 9.85.

Found at Sjö Mine, Örebro, Sweden, associated with tephroite.

Named Epigenite, but name changed on account of previous use for a copper mineral.—*Neues Jahrb. Min. Ref.*, 1890, ii., 222.

I'HOLIDOLITE, *G. Nordenskiöld*, $K_2(Fe, Mg)_{12}Al_2Si_{13}O_{38} + 5H_2O$.

Occurs in tabular twinned crystals. $G. = 2.408$; lustre, pearly; color, grayish-yellow.

Analysis shows: SiO_2 , 49.78; Al_2O_3 , 6.31; MgO , 27.94; FeO , 4.08; MnO , 0.12; K_2O , 5.93; H_2O , 5.49.

Found at Taberg, Wermland, Sweden.—*Amer. Journ. Sci. Abs.*, xl., 335.

PHOSPHOSIDERITE, *W. Bruhns and K. Busz*, $4FePO_4 + 7H_2O$. Orthorhombic.

Occurs in prismatic crystals, tabular parallel to $\infty p \infty$, cleavable in one direction. $H. = 3.75$. $G. = 2.76$; Color, peach-blossom red or pale reddish-violet; clear and transparent unless coated with iron oxide.

Heated in the tube, becomes yellow and opaque and yields much water without decrepitation. Before the blowpipe, melts easily to a black magnetic globule. Insoluble in hydrochloric acid, slightly soluble in nitric acid.

The mean of two analyses shows: P_2O_5 , 38.85; Fe_2O_3 , 44.30; H_2O , 17.26.

Found filling the cavities of a specimen of göthite from Kalterborn mine near Eiserfeld, Siegen.

The composition is very near that of strengite.—*Zeit. f. Kryst.*, xvii., 555.

PLEURASITE, *L. J. Igelström*.

Hydrous arseniate of iron and manganese. Massive, resembling magnetite externally. $H. = 4$; lustre, submetallic; color, bluish black; streak, black, opaque, but in thin sections pale red to violet; fracture, conchoidal; feebly magnetic.

Before the blowpipe, melts to a black magnetic button, evolving

arsenic odor. Easily soluble in dilute hydrochloric acid to yellow solution. In tubes, yields water. With fluxes reacts for Sb, Fe, Mn, Cl.

Found at Sjö mine, Orebro, Sweden, associated with arseniopleite.—*Neues. Jahrb. Min. Ref.*, 1890, ii, 222

PRISMATIN, *Sauer*.

A silicate of Al_2O_3 , MgO , FeO and N_2O , occurring in thick rhombic prisms or in radiated groups. Color, pearl gray. Found at Waldheim, Saxony.—*Zeit. d. d. Geol. Gesellsch.*, xxxviii., 704.

QUETENITE, *Frenzel*, MgSO_4 , $\text{Fe}_2\text{SiO}_4 + 13\text{H}_2\text{O}$.

Occurs massive; $\text{H} = 3$; $\text{G} = 2.08-2.14$; color, reddish-brown.

Analysis shows: SO_3 , 37.37; Fe_2O_3 , 22.70; MgO , 5.92; H_2O , 34.01.

Found at Salvador Mine, Quetena, Chili.—*Amer. Journ. Sci. Abs.*, xl., 259.

ROSEITE.

A brownish mineral resembling altered mica or chlorite found by Dr. Rose in West Nottingham, Chester county, Pa. Crystals yielded without previous drying. SiO_2 , 35.38; Al_2O_3 , 30.30; MgO , 14.66; H_2O , 19.88. Dr. Genth, who made the analysis, did not consider the material perfectly pure and did not endorse it as a new species.

SELEN TELLURIUM, *E. S. Dana and H. L. Wells* (*Te, Se*), *Hexagonal*(?).

Occurs massive, or with indistinct columnar structure. Cleavage parallel to prism of 60° ; lustre, metallic; color, blackish-gray; streak, black.

Analysis shows: Se, 29.31; Te, 70.69.

Found at El Plomo mine, Tegucigalpa, Honduras.—*Amer. Journ. Sci.*, xl., 78.

SIDERONATRITE, *Raimondi*, $2\text{Na}_2\text{SO}_4$, $\text{Fe}_2\text{S}_2\text{O}_9 + 7\text{H}_2\text{O}$.

In fine fibrous masses with small prismatic crystals probably orthorhombic. $\text{H} = 1.5$. $\text{G} = 2.355$; color, pale orange to straw yellow. Mean analysis shows: H_2O , 17.07; SO_3 , 44.22; Fe_2O_3 , 21.77; Na_2O , 16.39.

Found at Mina de la Compania, Sierra Gorda, Tocopilla, Chili. Associated with ferronatrite in white particles and lamellar masses.—*Amer. Journ. Sci.*, xl., 201.

SIGTERITE, *Rammelsberg* (Na, K), $\text{Al}_2\text{Si}_2\text{O}_{10}$.

Described as a new feldspar of gray color, cleavage like orthoclase and polysynthetic twining. $\text{G} = 2.6-2.62$. Analysis shows, after deducting admixed augite: SiO_2 , 50.54; Al_2O_3 , 30.64; Na_2O , 14.58; K_2O , 4.24. Equivalent to anhydrous natrolite. Albite and Sigterite are related as follows:

Albite	$\text{R}_2\text{Al}_2\text{Si}_4\text{O}_{16}$	R_2O , Al_2O_3 , 6SiO_2 .
Sigterite	$\text{R}_2\text{Al}_2\text{Si}_2\text{O}_{10}$	R_2O , Al_2O_3 , 3SiO_2 .

Found at Sigterö, near Brevig, Norway, associated with eudialyte and

albite. Named after locality in which it occurs.—*Neues Jahrb. Min.*, 1890, ii., 70.

SILICA.

M. Mallard divides all crystallized silica into two groups.

1. Quartz: uniaxial and with rotary polarization, but owing these to molecular grouping of some biaxial substance, perhaps chalcedony or some elementary substance yet unknown.

Crystals of this family may form at low temperatures and are stable only to about 1000° , above which they slowly lose their crystalline structure, become amorphous and opaque and may recrystallize as crystals of the second group.

2. Crystalline silica of G. about 2.2. It includes two distinct species, Tridymite triclinic, pseudo-hexagonal below 130° , hexagonal at higher temperatures. Cristobalite, orthorhombic, pseudo-isometric, below, cubic above 175° .

The crystal of this second family are formed, perhaps exclusively, at high temperatures; they are unchanged at all temperatures below fusion, but are more easily affected by solvents than the first group.—*Bull. Soc. Franc. Min.*, xiii., 176.

SPHALERITE.

A nearly pure white and amorphous sulphide of zinc has been found at Galena, Cherokee Co., Kansas. The ore-bed consists of sphalerite and some galenite. In the centre of the bed is a soft white substance resembling ground white lead. Surrounding it on all sides are partially decomposed ore and siliceous gangue rock showing casts of dissolved sphalerite crystals.

Analysis showed: Insoluble, 2.52; Zn, 63.70; S, 30.77; Fe_2O_3 , 2.40.

The original sphalerite is supposed to have oxidized to sulphate, which was removed in solution and, by the action of H S or an alkaline sulphide, the zinc reprecipitated as sulphide.—*Amer. Journ. Sci.*, xl., 160.

STIBIATIL, *Igelström, Hydrous Antimoniate of Iron and Manganese. Monoclinic.*

Occurs in columnar crystals with rectangular cross-section. H. = 4. Lustre, metallic; color, black; streak, black with touch of brown; opaque.

Before the blowpipe, infusible. In tube, yields water. Easily soluble, in cold dilute hydrochloric acid to yellow solution. Analysis shows: Sb_2O_3 , MnO, FeO.

Found at Sjö mine, Örebro, Sweden; associated with polyarsenite.—*Neues Jahrb. Min. Ref.*, 1890, ii., 222.

SYNADELPHITE, Orthorhombic not Monoclinic.—*Neues Jahrb. Min. Ref.*, 1890, ii., 226.

TAMARUGITE, *Schulze, $\text{Na}_2\text{Al}_2(\text{SO}_4)_4 + 12\text{H}_2\text{O}$.*

Occurs in massive forms, with radiated structure. H. = 2. G. = 2.03. Colorless. Found at Tarapaca.—*Amer. Journ. Sci. Abs.*, xl., 258.

TRIDYMITÉ.

The so-called tridymite of Mont. Euganeens, although agreeing exactly in form with other tridymite, is optically and in Sp. G., quartz. It is therefore quartz after tridymite.—*Bull. Soc. F. Min.*, xiii., 162.

VIVIANITE.

Found in stratum of clay on banks of the Cumberland River, near Eddyville, Ky, replacing the roots of coniferous plants.—*Amer. Journ. Sci.*, xl, 120.

WEIBYEITE, Brögger $(CeF)_2(CO_3)_2$ Orthorhombic.

Crystals small resembling zircon but optically proved to be orthorhombic. Colorless, but coated with ochre yellow crust.

Analysis shows: CO_2 , 19.16; Ce_2O_3 , 35.38; $(La_2O_3\ Di_2O_3)$, 31.58; CaO , 3.42; SrO , 0.97; F , 5.04; H_2O , etc., 6.34. Occurs at Arö, Norway, at the endidymite locality. Named after P. C. Weibye.—*Zeit. f. Kryst.*, xvi., 651.

BOOK REVIEWS.

THE METALLURGY OF STEEL. By Henry Marion Howe, A. M. (Harvard), S. B. Vol. I. Royal Quarto. pp. 380. Scientific Publishing Co., 27 Park Place, New York. Price: \$10.00.

The first edition is already exhausted. The second edition is forthcoming if not already on the market.

The greater part of this work has appeared in a series of papers issued as supplements to the *Engineering and Mining Journal* during the past two years, the present volume being a rearranged collection of these papers with considerable additional matter.

The great magnitude of this subject renders any thorough work on it of large size. This volume of the work contains: Chapter I., Classification and Constitution of Steel; Chapter II., Carbon and Iron. Hardening, Tempering and Annealing; Chapter III., Iron and Silicon; Chapter IV., Iron and Manganese; Chapter V., Iron and Sulphur; Chapter VI., Iron and Phosphorus; Chapter VII., Chromium, Tungsten, Copper; Chapter VIII., The metals occurring but sparingly in Iron; Chapter IX., Iron and Oxygen; Chapter X., Nitrogen, Hydrogen, Carbonic Oxide; Chapter XI., The absorption and escape of Gas from Iron; Chapter XII., The prevention of Blowholes and Pipes; Chapter XIII., Structure and related subjects; Chapter XIV., Cold Working. Hot Working, Welding; Chapter XV., Direct Processes; Chapter XVI., Charcoal-Hearth Processes; Chapter XVII., The Crucible Steel Process; Chapter XVIII., Apparatus for the Bessemer Process; Appendix I., Special Steels; Appendix II., Anti-Rust Coatings; Appendix III., Lead Quenching.

The book is illustrated by 228 drawings and 222 tables, some of the latter meriting particular attention, being in graphic form which enable the reader to grasp at a glance the significance of comparative data.

The masterly manner in which the author has handled the subjects treated, and his clear and comprehensive discussions cannot fail to win for him the admiration and thanks of all consulting his work and the endorsement which the author gives by referring to the long list of prominent metallurgists and practical workers in iron and steel, enhances its value as a work of practical importance.

To sum up, this work is of great merit, and is heartily recommended to engineers and others interested in the manufacture of iron and steel.

J. S.

REPORT OF THE ROYAL COMMISSION ON THE MINERAL RESOURCES OF ONTARIO, AND MEASURES FOR THEIR DEVELOPMENT. 566 pp. 8vo. Toronto. 1890. Warwick & Sons.

The scope of this work is indicated by the divisions assigned to the different members of the commission.

To Robert Bell, LL.D. The Geology of the Province with special relation to its Economic Minerals. Organization of a Bureau of Mines for the Province.

To W. H. Merritt, F. G. S. Detailed descriptions and maps of working mines and important undeveloped mineral properties, and all matters appertaining to mining engineering. Founding of a geological and mineralogical museum.

To John Charlton, M. P. Exports, imports, shipping facilities for ores, building stones, etc., and general inquiry into causes of depression in mining industry.

To Archibald Blue. Information and suggestions on mining laws and regulations. Inquiry into best methods of promoting metallurgical industry. Technical instruction in its relation to mining and metallurgy.

MINERAL RESOURCES OF THE UNITED STATES, Calendar year, 1888. David T. Day, Chief of Division of Mining, Statistics and Technology. 652 pp. Washington, 1890 (U. S. Geol. Survey).

This volume is the sixth of the series and continues the method of previous volumes, commencing with summary for the different metals and minerals irrespective of locality. Chapters by specialists are then devoted to each important mineral industry.

NINTH ANNUAL REPORT OF THE STATE MINERALOGIST OF CALIFORNIA. William Irelan, Jr. For the year ending December 1, 1889. 352 pp. Sacramento, 1890.

In addition to statistical chapters of production, etc., this volume contains special articles, notably, "Refining and Coining of Precious Metals," by Sven Gumbenner. "Auriferous Gravels of California," by Jno. Hays Hammond. "Insular Floras," by Lorenzo G. Yates. "Pottery," by Linna Irelan, illustrated. "River Mining," by R. L. Dunn. "Clays," by W. D. Johnston. The various articles are beautifully illustrated.

PRACTICAL SANITARY AND ECONOMIC COOKING, Adapted to Persons of Moderate and Small Means. By Mrs. Mary Hinman Abel. Prize Essays. Published by the American Public Health Association. English Text, 12mo. 182 pp. Paper, 35c.; cloth, 40c. English-German Text, 12mo. 364 pp. Paper, 55c.; cloth, 69c.

BULLETIN OF ALUMNI AND COLLEGE NEWS.

COLUMBIA UNIVERSITY.*

COLUMBIA COLLEGE at the present time consists of the School of Arts (the original college, founded in 1754), of sundry professional schools, to wit: the School of Law, the School of Mines, and the College of Physicians and Surgeons; and of the University Faculties of Law, Mines (Mathematics and Pure and Applied Science), Political Science, and Philosophy.

The point of contact between the college and the university is the senior year in the School of Arts, during which year students in the School of Arts pursue their studies, with the consent of the Faculty of Arts, under one or more of the University Faculties.

UNIVERSITY COUNCIL.—The various schools are under the charge of their own faculties, and for the better conduct of the strictly university work, as well as of the whole institution, a University Council has been established. This Council is an advisory body. In particular it advises the president as to all matters affecting the master's and the doctor's degree, the correlation of courses, the extension of university work in new and old fields, and generally as to such matters as the president brings before it.

The Council, for 1890-91, is composed as follows:

From the Faculty of Philosophy—

The Dean, Prof. Butler; Prof. Harry T. Peck.

From the Faculty of Political Science—

The Dean, Prof. Burgess; Prof. R. M. Smith.

From the Faculty of Mines—

The Dean, Prof. Chandler; Prof. Newberry.

From the Faculty of Law—

The Warden, Prof. Dwight; Prof. Chase.

From the School of Arts—

The Dean, Prof. Drisler; the Secretary of the Board of the College, Prof. Van Amringe.

By the choice of the President—

Prof. Trowbridge; Prof. Price.

Secretary of the Council, Prof. R. M. Smith.

SCHOOL OF ARTS.—The college proper has a curriculum of four years' duration leading to the degree of Bachelor of Arts.

UNIVERSITY FACULTIES.—These together constitute the University. The faculties offer advanced courses of study and investigation, respectively, in (*a*) Private or Municipal Law, (*b*) Mathematics and Pure and Applied Science, (*c*) History, Economics, and Public law, and (*d*) Philosophy, Philology and Letters. Courses of study under one or

* Condensed from Authorized College Bulletin, July, 1890.

more of these university faculties are open to members of the senior class in the School of Arts and to all students who have successfully pursued an equivalent course of undergraduate study to the close of the junior year. These lead through the bachelor's degree to the university degrees of Master of Arts and Doctor of Philosophy.

PROFESSIONAL SCHOOLS.—These are the schools of Law, Mines and Medicine, to which all students, as well those not having pursued a course of undergraduate study as those who have, are admitted on terms prescribed by the faculty of each school as candidates for professional degrees.

1. The School of Law, established in 1858, offers a three years' course of study in common law and equity jurisprudence, medical jurisprudence, criminal and constitutional law, international law public and private, and comparative jurisprudence. The degree of Bachelor of Laws is conferred on the satisfactory completion of the course. The courses in constitutional and international law and comparative jurisprudence are conducted by the Faculty of Political Science.

2. The School of Mines, established in 1864, offers the following courses of study, each of four years' duration, and each leading to an appropriate professional degree, namely, mining engineering, civil engineering, metallurgy, geology and palæontology, analytical and applied chemistry, architecture; and the following as graduate courses, each of two years' duration and each leading to an appropriate degree, namely, sanitary engineering and electrical engineering.

3. The College of Physicians and Surgeons, by joint resolution of June 18, 1860, the Medical Department of Columbia College, offers a three years' course of study in the principles and practice of medicine and surgery, leading to the degree of Doctor of Medicine.

MASTERS AND DOCTORS DEGREES.—Any student who has taken his baccalaureate degree either in Columbia College or in some other college maintaining an equivalent curriculum (every such case of equivalence to be considered on its own merits) shall be entitled, with the approval of the president, to become a candidate for the degrees of master of arts or doctor of philosophy.

Each candidate shall, immediately upon registration, designate one principal subject and two subordinate subjects, which when approved by the proper faculty shall be the studies of his university course. Should the subjects designated by the candidate fall within the jurisdiction of more than one university faculty, the candidate's selection must receive the sanction of the president before it is recorded.

Candidates must pursue their studies under the direction of the professors and other officers of instruction in charge of the subjects selected, attending such lectures as may be designated, and performing faithfully such other work in connection therewith as may be prescribed.

THE AVERY ARCHITECTURAL LIBRARY.—

4 EAST 38TH ST., NEW YORK, June 23, 1890.

MR. SETH LOW, President Columbia College.

Dear Sir: With your consent and that of the Trustees of Columbia College we propose to establish the Avery Architectural Library in memory of our son, Henry Ogden Avery.

We propose (1) to give to Columbia College, for the purpose mentioned, the library, comprising volumes relating to architecture and the decorative arts, and other professional books, formed by the late Henry O. Avery, including one or more folios of original architectural drawings by the late Henry O. Avery; and in addition thereto (2) to give to the Treasurer of the Corporation such sums as may be required to pay for books purchased, as provided below, on notice of their purchase, previous to the 1st day of January, 1891, not exceeding fifteen thousand dollars, and also (3) to give to the Treasurer of the Corporation on the 1st day of July of this year the sum of fifteen thousand dollars to be invested and to form a permanent fund, the interest of which is to be employed first in binding and making the necessary repairs of the books forming said Avery Architectural Library, and second in the purchase of newly published books, or others, under the conditions stated below.

It is our wish that the purchases made for the Avery Architectural Library be made exclusively by a commission of three persons, namely, the Librarian of Columbia College, the Professor or acting Professor of the Architectural Department of the School of Mines, and Mr. Russell Sturgis, of New York, whose successor, in case of his declination at any time, is to be selected by the other two members of the commission as above, to be always an architect and not immediately connected with Columbia College.

It is our wish also that the books so purchased, including those coming from the late Henry O. Avery, shall be kept together in one room, alcove, or the like, to be set apart and designated for the purpose and approved by the commission of purchase, but without impairing in any way the constitutional control of the college property vested in the Trustees by the charter, and that they be kept as a library of reference only, and not allowed to leave the library building except on special occasions, as for binding, repairs, etc., or for the purpose of having photographic or other copies made of plates and the like, but always on the express approval of the commission of purchase, or a majority of it.

It is also our wish that a tablet, or some other form of record, which we will furnish, be put in a prominent position, and always retained, in the room or alcove devoted to the Avery Library, and that a book-plate be pasted inside the cover of each volume of the library, the said tablet and book-plate to state the foundation of this library by the parents of Henry Ogden Avery in his memory.

It is also our wish that, at the discretion of the Trustees, a separate catalogue of this library from time to time be printed in pamphlet form, at the expense of the college, and that copies of it in sufficient number be furnished the commission of purchase for free distribution to architects, students of art, and other persons or institutions to whom the Avery Architectural Library may be useful.

(Signed) SAMUEL P. AVERY,
MARY A. AVERY, pr. S. P. A.

EXTRACT FROM THE WILL OF CHARLES M. DA COSTA, an alumnus of the class of 1855 and a trustee of the college, who died on Sunday, June 22, 1890:

"FIRST.—I give and bequeath to the Trustees of Columbia College in the City of New York the sum of one hundred thousand dollars. I express the hope that such sum may be used for the endowment of some new professorship, which, in the good judgment of the Board of Trustees, may be needed in any of the schools or departments of the college. But this expression is in no way to limit the absolute right of the said corporation to use the said sum for any of its corporate purposes. I also give and bequeath to said corporation my library, both law and miscellaneous."

COLUMBIA ALUMNI ATHLETIC CLUB.—Over six hundred names have been obtained for the formation of the Columbia Athletic Club. The articles of incorporation are as follows:

CERTIFICATE OF INCORPORATION.

We, the undersigned, being of full age, citizens of the United States, and also of the State of New York, desire to form ourselves into a club for Athletic, Gymnastic and Social purposes, in accordance with the provisions of an Act entitled "An Act for the incorporation of societies or clubs for certain lawful purposes," passed May 12, 1875, and we do hereby certify—

Name.

1. The name or title by which said club shall be known is THE ALUMNI ATHLETIC CLUB OF COLUMBIA COLLEGE.

Object.

2. The object of said club is to provide for the graduates of Columbia college, and such others as they may associate with them, social privileges and opportunities for athletic exercise for themselves and, under certain restrictions, for the undergraduates of the College.

Trustees.

3. The number of Trustees to manage the affairs of the club shall be seventeen.

The names of the Trustees for the first year are as follows:

John H. Van Amringe, George G. DeWitt, Jr., George Sherman, John Krom Rees, Robert C. Cornell, Jasper T. Goodwin, William Fellows Morgan, J. West Roosevelt, William G. Lathrop, Jr., Nicholas Fish, Robert Fulton Cutting, P. de Peyster Ricketts, Isaac N. Seligman, T. J. Oakley Rhineland, J. Adriance Bush, Charles E. Pellew, Lincoln Cromwell.

In witness thereof we have hereunto set our hands and seals this tenth day of June, in the year one thousand and eight hundred and ninety.

F. R. Coudert, G. Sherman, F. S. Bangs, Julien T. Davies, D. Morgan Hildreth, Jr., Edward Mitchell, John Murry Mitchell, Jasper T. Goodwin, Michael I. Pupin, Charles Halsted Mapes, John M. Knox, S. Victor Constant, Edward S. Rapallo, Abm. Van Santvoord, S. Albert Reed, Theodore W. Dwight, P. de P. Ricketts, J. K. Rees, Wm. G.

Lathrop, Jr., Charles F. Chandler, George G. DeWitt, Jr., Wm. S. Sloan, Wm. Manice, Joseph Lawrence, Stuyvesant Fish, Edgar J. Levey, Robert C. Cornell, Henry R. Beekman, Henry Phelps Chase, Nicholas Fish, Charles A. Jackson, Edward L. Patterson, Jos. Larocque.

At the first meeting of Trustees Prof. Van Amringe was chosen temporary Chairman, Prof. Ricketts temporary Secretary. The Chairman has appointed the following committees:

Committee on Finance.—R. Fulton Cutting, J. Adriance Bush, George Sherman, Isaac N. Seligman, Wm. Fellowes Morgan, P. de Peyster Ricketts, *ex officio*.

Committee on Constitution and By-Laws.—Jasper T. Goodwin, John K. Rees, Robert C. Cornell, J. West Roosevelt, Lincoln Cromwell, P. de Peyster Ricketts, *ex officio*.

Committee on Permanent Organization.—George G. DeWitt, Jr., William G. Lathrop, Jr., Nicholas Fish, T. J. Oakley Rhinelander, Charles E. Pellew, P. de Peyster Ricketts, *ex officio*.

DEPARTMENT OF MINERALOGY AND METALLURGY.

METALLURGY.—The metallurgical collection has recently received some very important additions. Last spring the Dixon Crucible Company sent a collection of its products of manufacture, which is one of the largest and most important additions made to the metallurgical collection of the school for a long time. The intention of the company is to eventually send all the raw materials as well as the products of manufacture, but the raw materials have not yet arrived. The manufactured articles consist of 28 crucibles, the largest of which is 26½ inches high and 13½ in diameter, there being ten above 10 inches in height and seven above 15 inches. The smallest of these crucibles is 2 inches by 1 inch and 3½. Besides these there are Bessemer stoppers, ladle stirrers, gold and silver stirrers and zinc retorts, which show a complete assortment of their manufactures. This is an extremely valuable as well as interesting addition to the collection and is a very important addition to the collections of the school.

One of the most interesting and at the same time most valuable additions to the metallurgical collection that has been made in many years has been recently received from Tiffany & Co., and consists of electrotype copies in copper of some of the most famous of their works. These include the Demidoff tankard, which is probably the most beautiful and artistic specimen of repoussé silverware that ever was executed, and the Morgan salver, which is one of the most artistic specimens of flat chasing that has been made. Besides these there are 8 plants, 2 flowers and 3 leaves, copied from nature, showing both sides and reproducing all the delicate lines and being about as thin as the natural leaf; 4 animals, a crab, a tortoise, a rabbit's head and a horse-shoe crab, showing both sides with all their delicate traceries; 6 remarkably fine specimens of fine saw cuttings for silver-ware; a copy of the Gladstone silver bust presented to Mr. Gladstone by his admirers in the United States, the cast in copper being taken from the mould in which the silver casting was taken; a medallion of William Cullen Bryant taken from the silver memorial presented to him on his 80th birthday; a small repoussé copper dish covered with a coating of red sub-oxide of copper,

formed upon it naturally; 28 specimens of alloys, representing in detail the famous Shak-udo and Shibushi, made by sweating gold, silver and copper together, then cutting out parts of the various layers, of which the famous vase exhibited at the Paris Exhibition of 1889 was made. In addition to these are specimens of steel and brass spinning of metal to show how silver and other metals are spun from the flat. Some of the sprigs of plants are over 18 inches in length and represent the plant exactly as it is found in nature. This is the most valuable collection of artistic metal work ever presented to the school.

MINERALOGY.—The mineralogical collection has just received from A. M. Hoyt, Esq., 6 specimens of argentite; 5 of these are handsome specimens with very large crystals. The other is 5 x 8 inches and is covered with large-sized and well-developed crystals, and is believed to be the handsomest single specimen which ever came to this country.

Mr. F. A. Heinze has presented to the collection a cluster of large enargite crystals which show the prism and the basal pinacoid; the largest crystal of the group shows a prism face three-eighths of an inch broad. The smaller prisms are evidently compound crystals, the faces showing deep vertical striations.

The collection is now being recatalogued, so many specimens having been transferred to conference and student collections that the accuracy of present catalogue is impaired. A great deal of work has been done since 1887 upon the mineralogical collection. In the eight years between 1879 and 1887 only seventy-five new species were added. In 1887 the increased force of the department made possible the preparation of a list of all missing species and varieties, and in the two ensuing years two hundred and five new species and one hundred and thirty new varieties were added. It is believed that in completeness the collection will now bear comparison with any in the country. A revised list of desiderata has now been prepared, and it is hoped that all procurable species will soon be represented. Twenty-four wall brackets for large specimens have been put up.

DEPARTMENT OF ENGINEERING.

MECHANICAL.—An interesting extension of the facilities of the department in the line of mechanical engineering has been recently effected. It is an effort to render more useful for purposes of instruction and practice the very considerable steam and power plant which the College is compelled to operate for purposes of administration. The President has accepted a suggestion that fourth-year and graduate-students in engineering to be designated by the professor of this subdivision, be allowed access to the engine and boiler rooms in pairs, between the hours of two and six in the afternoon, during which time they shall be under the orders and direction (but of course without pay) of the college engineer who operates the engine plant, and shall do such labor around the engines and in the repair shops as he may direct. They shall have as much part in the actual manipulation of the machinery as they shall show themselves qualified for.

These appointments are, of course, optional and voluntary for the present, but if the plan proves successful and popular, such assignments

to practical work may in time be made a regular feature of a late part of the engineering courses.

These facilities and opportunities will, of course, be of special use to the students in electrical engineering, as they will give them valuable practical familiarity with the running of a plant for incandescent lighting.

The development of the work in mechanical engineering has called for the appointment of an assistant in that department, who will have special charge of the laboratory work, to be extended as rapidly as increase of facilities will permit.

MINING.—The Summer School of Practical Mining, visited this summer the Lake Superior Copper region. Five weeks were spent at the Osceola Mine and one week in the Marquette iron region. The class was under the charge of Professor Munroe and Mr. Woolson.

THE Summer School of Surveying was held at Litchfield, Conn., as usual. The new two-year course inaugurated last year went into full effect this summer. All maps and computations are now completed before leaving Litchfield. Professor Munroe's assistants this year were Mr. R. E. Mayer, T. T. Luquer, A. H. Freedman, G. J. Volckening, Jr., and H. S. Ives.

ELECTRICAL.—The second year of this course has started under circumstances even more favorable than last year. There are six students in the second-year class and fourteen in the first-year class. A considerable number of new pieces of apparatus have been added to the collection, in addition to the set of measuring instruments purchased last year. Among the most important of these may be mentioned a very large electro-magnet, with adjustable pole piece for experimental work, complete set of photo-metric apparatus and a large induction coil. But the most important acquisitions are in line of practical machines. These include an electric-lighting plant consisting of a twenty-five horse-power high-speed engine, a 200-light incandescent dynamo driven from one pulley of the engine and a four light arc dynamo driven from the other pulley, incandescent and arc lamps, switches, ampère meters, lightning arresters, etc. This plant is entirely separate from the 1000-light incandescent plant used for lighting the college buildings and is of such size as to be easily handled and run by the students and yet sufficiently large to be complete in every detail and thoroughly practical. A screw-cutting engine lathe, run by a one horse-power electric motor, has also been provided for the use of the students in making electrical apparatus in connection with their work. A five horse-power motor is set up ready to run small dynamos and other machines for testing purposes; storage batteries, transmission dynamometer, large rheostats for heavy currents, and other practical apparatus are also provided for this year's work.

The instruction both in lectures, which occupy about ten hours per week for each class, and in laboratory work, to which twenty hours per week are devoted, is thoroughly practical and at the same time sufficient attention is given to the theory of the subject to give the student a good foundation to his knowledge.

DEPARTMENT OF CHEMISTRY.

ANALYTICAL.—The Trustees have created the position of Assistant in the Quantitative Laboratory, and Mr. H. C. Bowen has been promoted to that position—a promotion well deserved.

The position of Fellow in the Quantitative Laboratory, hitherto held by Mr. Bowen, has been filled by the transfer of Dr. H. T. Vulté to that laboratory. His work will be, to a considerable extent, the examination of new methods of analysis, a work of great value and importance. The position of Fellow in the Quantitative Laboratory is for the present filled by Chas. Bullman, Ph.B. of '83.

ORGANIC.—The Organic Laboratory has been moved from the old building to the first floor of the School of Mines' Building. The fourth-year chemists now occupy four alcoves at the east end of the Qualitative Laboratory, Dr. Wells and his students retaining the west portion, while Prof. Colby occupies the room vacated by Dr. Vulté.

The change was accomplished during the first week in October, with little inconvenience to those concerned, the chief difficulty being to find sufficient storage room for apparatus and chemicals.

The four alcoves have been fitted with steam, water and waste and exhaust pipes, so that the students in Organic Chemistry now have the same facilities which existed in the old place. The lecture-room for Organic Chemistry in the old building is retained for the present.

ARCHITECTURAL DEPARTMENT.

The Department of Architecture begins the new year, for the first time in its history, with a decrease in the total number of its students as compared with last year. This is due to the severe pruning out of the three upper classes, resulting from conditions imposed at the examinations last summer. A considerable number of students have either abandoned the pursuit of architecture, or have decided to continue its study in offices or in other schools. On the other hand, the first-year class counts no less than thirty-seven members, of whom four have entered as repeaters and two as students from the School of Arts. The first class, under the special charge of Mr. C. A. Harriman, occupies the third floor of the "President's House," the rooms used last year by the second class.

The exercises in elementary design in the second class are proving very interesting and successful as conducted by Prof. Ware. They will constitute a valuable preparation for the more serious work in design of the third and fourth years.

Of last year's graduates all but two have found employment in architects' offices, several of them in very advantageous and responsible positions. Of the two not engaged in practice, one has abandoned architecture for the drama, and is a member of Daly's company, while the other expects to be "placed" very soon. This is an excellent record for a class whose whole course in college was creditable.

THE SCHOOL OF MINES QUARTERLY.

VOL. XII.

JANUARY, 1891.

No. 2.

THE TREATMENT OF COPPER SLATES AT MANSFELDT.

By T. EGLESTON, PH.D.

THE copper-mines of Mansfeldt* are the oldest of all the copper-mines now working in Europe. They produce the third largest quantity of copper made by any single company working anywhere in copper. It is one of the largest and best conducted enterprises in Europe, supporting directly and indirectly about 50,000 men, women and children. It mines a lean ore from thin beds through ten shafts from wet mines and produces some of Europe's best copper. As compared with what is done in our own country, the work there is very surprising. It is possible only because the wages at Mansfeldt are less than half of those of the copper districts of Lake Superior and less than one-quarter of those paid in the copper regions of Montana and Arizona. The average yield in copper is greater than any mine on Lake Superior except the Calumet and Hecla, and, taking into account the silver contents

* This paper is the result of two visits to the Mansfeldt works, made for the purpose of writing it, the last of which was made in September, 1890. I was not allowed to see processes No. 5 to 9. A great deal of information has been furnished to me by the company in answer to inquiries, and has also been obtained from two pamphlets published by the company, the one in 1881, and the other in 1889, from which all the analyses and statistics have been taken. The drawings were furnished me by the company at my request.

of the ore, its value is greater than any mine in that district, but the processes required to extract it are much more complicated and delicate. The works have been the laboratory in which many of the most important discoveries in copper and silver metallurgy have been made and the place in which the most delicate metallurgical processes for the separation of copper and silver have been successfully invented and carried out. They have set an example to the whole world in the care and economy with which all the by-products are utilized and made to increase the profits of the works; nor are its hospitals and schools to be left out of account in summing up all the reasons why, with many disadvantages, it is able successfully to compete with other enterprises more favorably situated. The process as a whole is not applicable in this country, but many of its details are, and very much can be gained by the study of its methods both of administration and working.

The early history of the works is somewhat obscure. The first mention of them appears in the "History of Mansfeldt," written in 1572, which says that mining was done in 1199 at Hettstedt, not far from Mansfeldt, where there are works to-day. According to other authorities, a Count Mansfeldt commenced the working of the ore in 1215. Others say that it was not until 1364 that his successor commenced, but it seems quite certain that the Counts of Mansfeldt mined long before 1215. The district around Hettstedt does not appear to have belonged to the Counts of Mansfeldt previous to 1439, but they worked mines in it and paid royalties to the emperors long previous to that time. During the 15th century, they produced 2000 tons of copper a year. In 1536, there were 95 small furnaces at work. As the furnaces all ran by charcoal, a law was made at that time that no more furnaces should be built, as there was not wood enough in the country to supply them all. This order does not seem to have been obeyed very long. About this time a number of furnaces went into private hands, and in 1568 a law was passed regulating the way in which the whole of the mining and smelting should be conducted, in which the rights of the Counts and of the private persons owning works were defined.

The Counts of Mansfeldt were brave soldiers and spent money lavishly both at court and in war, but they were no financiers. In 1570, their debts having reached the sum of two and a half mil-

lion of guldens, three-fifths of their property went to their debtors. Up to 1780, when their family died out, their debts were over a million of guldens. During the thirty years' war the mines were almost destroyed, but in 1648 the Prince of Saxony, to which a large part of the territory had fallen, took the property in charge, and finding that almost all the shafts and gangways had fallen in, made, in the year 1671, mining in the territory free under specified conditions. As the property was productive when there were no debts upon it, several companies were formed in the years 1674 and 1675 to work the mines. They built at once four works, and a little later, two others, most of which exist under the same names to-day. These were:

Ober Hütte, near Eisleben; Creutz Hütte, near Leimbach; Mittle Hütte, near Eisleben; Silber Hütte, near Mansfeldt.

Then a little later:

Wiesen Hütte, at Gross Oerner, and Gottesbelohnungs Hütte, at the same place.

In 1723 Kupferkammer Hütte near Hettstedt was built.

These were worked by separate companies until 1852, when they were all consolidated into the Mansfeldt Copper Slate Mining Company. Connected at present with this company there are eleven works. The principle on which they are conducted is to preserve the old works as far as possible and, at the same time, to so carry on the work of concentration that only valuable products will be transported any distance. To serve this purpose, most of the shafts are connected with the furnaces and the furnaces with each other by rail, for which purpose the company own 18 locomotives and 446 wagons. The ores which are to be brought to Krug Hütte are carried by an overhead wire rope-way and are delivered automatically. Only those which are brought to Koch Hütte are transported over ordinary roads. Of the eleven works, four are used for roasting the raw matte, two for roasting and concentration, two for grinding and desilverization, one for refining, one for treating scorias and two others for hammering and rolling.

These works are situated in or near the following towns, commencing at the south:

Sangerhausen. Kupfer Hütte. Abandoned in 1885.

Eisleben.	{	Krug Hütte.	
		Ober Hütte.	
		Mittel Hütte.	Abandoned.

Helbra.	Koch Hütte.
Leimbach.	{ Eckhardt Hütte.
	{ Creutz Hütte. Abandoned.
	{ Katherinen Hütte.
Hettstadt.	{ Silber Hütte. Abandoned.
	{ Gottesbelohnungs Hütte.
	{ Kupferkammer Hütte.
	{ Seige Hütte.

The map, Fig. 1, shows the situation of all the works and the means of transportation, both by railways and roads, and also the private railways belonging to the company. Creutz Hütte, Silber Hütte, Mittel Hütte and Kupfer Hütte have been entirely abandoned and the property sold. Katherinen Hütte is only used for grinding the matte for desilverization. Since 1880, the company have employed over 10,000 men. In 1888, they employed 14,178, 13,960 of whom were engaged in mining. In that year, 469,716 tons were extracted at a cost of 35.14 marks* per ton.

The ores are composed mostly of chalcopyrite and chalcosite, with small quantities of galena, blende, arsenopyrite and pyrite, associated with very small quantities of the ores of nickel and cobalt, and occur as slates in beds in the Permian formation between walls of sandstone and compact limestone. These beds vary from 0.34 m. to 0.55 m. in thickness, but only a few centimetres are worth mining. The miners divide the beds into nine layers which they distinguish and work, though to the unpracticed eye but very little difference is seen between them. The ores are covered by beds of gypsum, which sometimes contains rock salt. As a general thing the lower layers of the ore contain the most silica and bitumen, while the upper ones contain more carbonate of lime. This allows of their being mixed in the furnace in such quantities as to make the charge self-fluxing. In the year 1889, the mines produced 511,323 tons of ore at a cost of 33.57 marks per ton. This was gained by the extraction of 1,459,360 square metres or 360.6 acres, or about 31 square feet per ton of mineral extracted. It may be said in general terms that the ore east of Eisleben contains 2 per cent. to 3 per cent. of copper and is the richest in silver; that the siliceous ores west of it contain from 5 per cent. to 10 per cent. and about half as much silver as those to the east; those to the north contain about

* A mark is equal to about twenty-five cents.

1 ½ per cent. of copper and about the same amount of silver as those

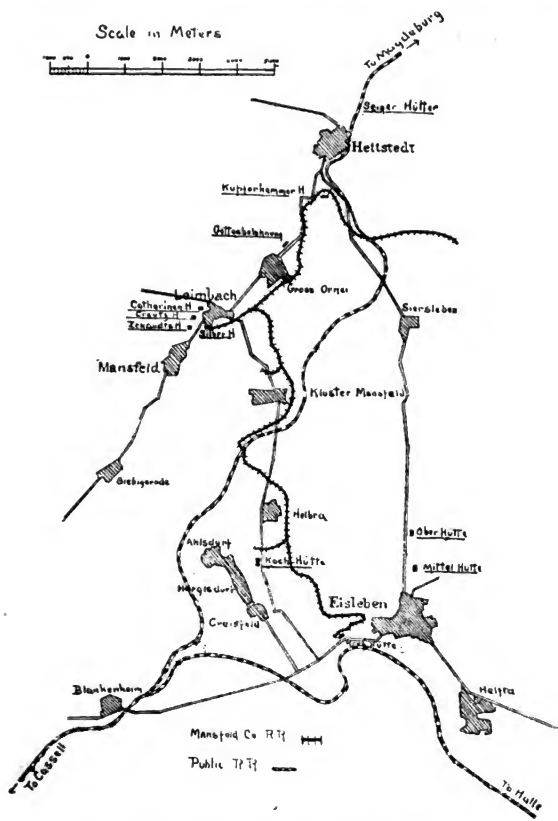


FIG. 1.—Map showing the position of the Mansfeld works.

to the west. As they came from the mine in the year 1879 the ores had the following composition :

	Otto Shaft. Right side.	Otto Shaft. Left side.	Ernst Shaft. Left side.	Glückhilt Shaft. Left side.
Silica,	38.42	32.87	33.15	29.22
Lime,	10.93	14.31	14.39	12.66
Magnesia, . . .	3.53	4.53	2.32	2.25
Alumina,	15.93	11.28	12.90	11.76
Iron,	1.81	0.85	3.31	2.97
Copper,	2.01	2.93	2.90	2.88
Silver,	0.015	0.01	0.016	0.021
Sulphur,	3.18	3.96	2.15	4.97
Carbonic acid, .	7.02	13.51	10.47	9.43
Bitumen and loss, .	14.63	14.07	9.89	17.21

They contain besides very small quantities of manganese, nickel, cobalt, zinc and lead, which were not determined. The ore is scattered irregularly through a bituminous slate in very fine particles. It can be seen with a glass but not by the eye except in the bright sunlight as very small specks, or where the pyrites is concentrated in some fossil, which is very often a fish. It requires a great deal of experience to see anything in the unroasted ore, but after roasting, a partial concentration of the sulphides takes place, so that the copper pyrites becomes visible in small grains. Within certain limits the composition of the ore is constant, and by long experience the workmen become accustomed to the kind and color of the rock, and can tell very nearly what the mineral contents of any particular ground in the mine will be, so as to mine or leave it. This fact is not sufficient for smelting purposes, as the ore frequently contains considerable zinc blende, which might lead into serious error. The assay of the ore was formerly made by taking an assay sample of a considerable quantity and smelting it in a shaft furnace, the same furnace being used for all the assays. As some of the ore was frequently not reduced or the residues of a previous melting were left in the furnace, it gave too high results. The ores are now assayed both by the colorimetric and the electrolytic method. Assays are made very frequently on the mine samples. To effect this the mine sample is broken to about the size of a walnut and then thoroughly mixed with a shovel. It is then made into square heaps about 0.15 m. high, which are smoothed over on the top and sides. From this pile the width of a shovel parallel to each side is taken and placed by itself; another is then taken parallel to the two diagonals and placed by itself. The remainder is then carefully shoveled over and made again into a pile and the width of the shovel taken from

each diagonal. This makes three assay samples from the mine sample pile. Each one of these is reduced to powder and a small laboratory assay sample taken from it, for the determination of the value of the ore.

The copper is determined as follows: Two grammes of the finely pulverized ore is placed in a porcelain crucible and heated in a muffle to drive off the volatile matter. It is then put into a beaker glass holding about 100 c.c., and 10 c.c. of a mixture of equal parts of nitric and sulphuric acid, with a few drops of muriatic acid poured on it, and heated on the sand-bath to dryness. The dry material is taken up with a mixture of one part of nitric acid and six parts of water, and warmed. The beaker is filled to two-thirds of its height; a few drops of concentrated acetic acid is added to it, and it is left for a short time. The whole is then submitted to an electrical current without filtration. The electrodes are a small cylinder of sheet platinum which is connected with the negative pole of a Meidinger's battery, and a platinum spiral which is connected with the positive pole. The copper goes down on the platinum cylinder, which has been previously weighed, in eight to ten hours, and has a beautiful rose-red color. It is dried and weighed and the copper in the ore is thus determined. The determination of the silver is made by melting with lead and cupelling.

The colorimetric assay, as made in the raw matte smelting works, is done as follows: Two grammes of the pulverized material is placed in a porcelain dish, heated to redness, carefully stirring all the while to burn off the bitumen. When cold, the ore is placed in a beaker glass with 15 c.c. of a mixture of three parts of sulphuric acid at 30° B., and one part of nitric acid at 36° B., and heated in a sand-bath until the sulphuric acid disappears, when it becomes thick. It is then taken up in a graduated glass which up to a certain mark contains one and one-half times the volume of a normal glass, and then 30 c.c. of pure concentrated ammonia added to it after which it is filled to the mark with water and stirred. It is then left to stand until the insoluble residue and the alumina and iron oxide have settled. Then a normal glass full is filtered off and the shade of color determined by comparison with a known quantity dissolved in a similar glass. This is sufficiently exact for all furnace work. The tubes for comparison are made in the laboratory upon ores whose value has been ascertained in exactly

the same way. The average composition of the ores is $2\frac{1}{2}$ per cent. to 3 per cent. copper and 0.015 per cent. of silver.

The process of smelting consists of nine operations, which are carried on in the different works as shown in the table below.

1. Calcining and burning the bitumen out of the slates, done at Krug Hütte, Koch Hütte, Eckardt Hütte and Kupferkammer Hütte.

2. Smelting for raw or first matte, done at Krug Hütte, Koch Hütte and Eckardt Hütte and Kupferkammer Hütte.

3. Roasting the raw matte and making sulphuric acid, done at Kupferkammer Hütte and Eckardt Hütte.

4. Concentration of the roasted matte to a richer matte, done at Kupferkammer Hütte and Eckardt Hütte.

5. Grinding, roasting, and desilverizing the concentrated matte.

a. Grinding. $\left\{ \begin{array}{l} \text{Katherinen Hütte for matte from Eckardt Hütte.} \\ \text{Gottesbelohnungs Hütte for matte from Kupfer-} \\ \text{kammer Hütte.} \end{array} \right.$

b. The Ziervogel process carried out at Gottesbelohnungs Hütte.

c. The electrical process carried out at Ober Hütte.

6. Smelting the cement silver, done at Gottesbelohnungs Hütte.

7. Making refined copper from the desilverized residues, done at Seige Hütte and Gottesbelohnungs Hütte.

8. Treating and refining copper scorias, done at Seige Hütte.

9. Hammering and rolling the copper produced, done at Rothenburg and Eterrwalde.

The roasting and matte smelting is thus done at four works, the matte concentration at two, the sulphuric acid is made at two, desilverization and electrolytic work at one each, the refining at two and the hammering and rolling at one each.

1. *Calcining the Ore and Burning the Bitumen out of it.*—This process is carried out at four different works as already pointed out. These works get their supply from the shafts nearest to them, or receive ore which is suited for their peculiar work from other shafts. The quantity of bitumen as well as the contents of the ore are not the same from the different districts, and hence, while the piles are all made in the same way, the details of the work vary slightly from one works to another. The ores are all brought from the various mines by road, by locomotive or by wire-rope tramway, which connect directly with the roasting yards. These yards, with

the exception of Koch Hütte, are situated at or above the level of the charging floor of the furnaces. After being weighed, all the ore is run over grizzlies, the bars of which are from 0.005 m. to 0.01 m. apart, to separate the coarse from the fines, which from some of the mines are in considerable quantities and from others in very small amount. The large pieces are roasted in long, narrow heaps, containing less than a thousand tons, which takes from four to five weeks. They were formerly roasted in large rectangular piles containing sometimes three thousand tons, which took six months to roast. This method has been abandoned for the smaller, narrower heaps, which have been found to be much more profitable, as much less capital is locked up in them and for a shorter time. The fines are slightly moistened and pressed by machines, driven by steam, into bricks about the size of an ordinary brick, and are either scattered through the pile of ore or are burned by themselves in a pile covered on the outside with unburned slate. All the roasting yards are paved with slag bricks. They are usually back of the furnaces. At Krug Hütte they are at one end of the line of furnaces. At Koch Hütte they are below the level of the furnaces. At Eckardt Hütte and Kupferkammer Hütte they are placed on the side of the hill above the top of the furnaces. The shape and size of the yard is determined by the lay of the ground, and varies from 100 to 300 m. in length and breadth. The piles are arranged in the same general way, which is usually at right angles to a wall. The height of the pile is generally from 2.5 m. to 3 m. These piles have usually the same height and width, but vary in length according to circumstances. The width is usually 4 m. on the ground and 2.5 m. on the top. The length varies from 10 m. to 200 m. The wall skirts the edge of the yard when it is of irregular shape, as at Krug Hütte, or is at one side as in most of the other works. In this wall steps are placed at regular intervals to go to the level of the bottom of the piles. The top of this wall is connected by mine road with the supply of the ore. At Krug Hütte this supply comes by wire-rope tramway in two opposite directions. All the wagons arrive at the same place on a high wooden platform, and are all shunted by one man, who empties them into shutes, from which the ore-wagons for making the piles are filled. The permanent lines of railway for these wagons end at the top of the wall, and are at right angles to it. In all the other

works, except Krug Hütte, the ore arrives either by train or by cart.

When the space for a pile is empty, the place which it is to occupy is outlined by making two piles 0.65 m. high and wide, which represent the outside of the pile which is to be built, leaving the space between the two empty. This is done by the man in charge of the roasting yard for the whole length which the pile is to be, when finished. On top of these two piles a little brushwood is laid and kept in its place by large pieces of ore laid on it. When this has been done, the ore is dumped from the top of the wall to the height of the two piles and made level with them for a short distance. A plate of sheet-iron is laid down at its end for the empty car to turn upon, and two rails bent up to catch the wagon and prevent it from filling over when it is emptied, and the ore is dumped from the wall into ore-cars on a level with the top of the low pile, and a certain length between the two piles is filled up with ore without any fuel. Rails are laid down on the top of the low pile so constructed, having sheet-iron at the end for a turntable. A large quantity of mine rail bound together by iron ties in lengths of 4 m. is kept constantly on hand, and this is used both for the purpose of constructing the piles and of taking them down. They are very quickly laid down and taken up. The pile is then finished to the height of the wall for the distance to which it is filled between the side, piles below, the tracks and turntables being put down as the pile advances. When this is completed, bent rails to catch the tipping cars and prevent them from falling on to the lower level are placed above, and another twenty metres of the pile is finished below to the height of the outside pile, and so on until the pile is completed. It generally does not take more than three or four days to build a pile holding 600 to 800 tons. There is a great advantage in building the pile in this way, both as to economy of construction and also as to the burning of the pile, for the constant transportation over the two sections of the pile serves to settle it and makes the passage of the air less easy, and when there has been an agglomeration from too much heat, makes the agglomerated masses in the heaps break up easier, so that they can be transported. These piles are placed together as closely as possible, only sufficient room to walk between them being left. When the pile is to be lighted, it is done along both sides of it with red-hot slag. This is placed both on the brushwood and under the

slates. There is sufficient bitumen in the slates for them to take fire easily, and the pile requires but little watching, except to see that it is well lighted at the start, after which it is left to itself. The burning takes place entirely in the open air, but the piles rarely go out. The piles vary from 200 to 800, or even a 1000 tons, depending on their length. It takes usually from four to six weeks to burn a pile, depending upon its size and the quantity of fines it contains. The ore loses from 8 to 20 per cent. in burning, most of which is bitumen, though some of the ores contain a little carbonic acid. The pieces do not differ in shape after burning, but are a little more friable. It is readily seen in the daytime that the piles are hot in the middle, but no flame is seen except at night, and then only a very short blue one.

In 1850 the analysis of the roasted ores was :

	From the 31st District.	From the Schafbreite District.	From the Glückauf District.	From the Sangerhausen District.
Silica, . . .	49	50	49.20	52.92
Lime, . . .	18.10	13.20	15.60	9.99
Magnesia, . .	4.14	3.30	4.50	4.65
Alumina, . .	15.31	18	16	15.67
Oxide of iron, .	8	8	8	8

The sulphur was not determined.

It was thought at one time that it might be desirable to save the bitumen in the slates. An attempt was made to distil it out in retorts, but it did not prove profitable.

The reactions which take place in the pile are very slight. The bituminous matters are volatilized and burned. The carbonic acid is driven off. A very small quantity of the sulphur and of the arsenic and antimony is driven off, but the main result is to get rid of the bitumen. When finished, the ore is, in most of the piles at the front, where the brushwood was used, more or less sintered. To overcome any inconvenience which might arise from this cause, the ore below this point is taken out first on both sides for some depth over a considerable length. The sintered part is supported by wooden props. When these are removed the falling of the top generally breaks up the sintered lumps, and those which are too large are usually broken up with a triangular hoe.

Flue-dust from the furnaces, when it does not contain lead, and the fines of the ore are made up into bricks and roasted in the piles. This is done by moistening them with water and pressing

them in a brick machine. When there is but a small quantity of the fines, these bricks are scattered through the piles of ore, but when there is a very large quantity of lead, as there frequently is at Eckardt Hütte, the dust is collected for a special treatment. At Koch Hütte and Kupferkammer Hütte the quantity of fines is so large that they are obliged to treat them separately. These fines come from the sifting of the ore at the mines which still contain bitumen and from the sifting of the ore at the piles which contain none. The two are mixed together by making a pile to which alternate shovels of the fine burned and unburned ore, previously wetted up with a little water, are thrown. When the pile is about 0.40 m. high and of the same diameter, it is mixed together and made in a machine into bricks 0.25 m. \times 0.12 m. \times 0.06 m. These are dried and burned. They are not very strong when they are finished, but are much better than the fines, and when burned are strong enough to be charged in the furnace. At Koch Hütte the quantity of fines to be treated is so large that they are burned in piles made exclusively for them. To do this a pile is laid out in the regular way, the bottom being prepared with ore as usual. On this the bricks are piled, leaving spaces between them for the air to circulate. This is done up to about 0.40 m. of the top. The sides are made to recede regularly in steps, leaving about the same space from the outside of the pile in each bed, so that the cover is supported in each layer about the length of one brick. The top and sides are made of the slates and the pile is burned in the ordinary way. This disposes in a very advantageous way of all the fines. In these piles copper sulphate is often seen on the surface of the bricks, while it is rarely seen on the ore. None of the roasting yards are completely covered with piles. There are always a larger number under treatment than being taken down, and plenty of space to build new piles. At Krug Hütte I counted ten that were 50 to 60 metres long or longer, with many others of smaller size.

When the pile is finished the ore is carried away in iron wagons which tip forward. Two piles are built very close together, but this causes no inconvenience in taking them down, for generally the two heaps together are being loaded into wagons, and they are so arranged that when the rails cannot be laid on both sides of the pile, they can be in front of each, and then as the end is removed faster from one than the other, one at least of them can

be attacked from both sides and the end. If the pile contains 600 to 800 tons, it has taken three days to build it, four weeks to

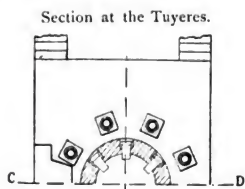
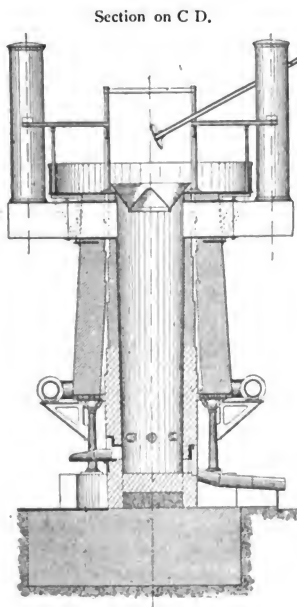
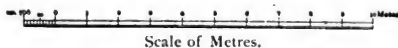


FIG. 2.—Krug Hütte Furnaces.



burn it and eight days to take it down, so that every ore-roasting

heap space may be occupied at least eight times a year. The piles are quickly taken down, as in two of them the incline is from them towards the top of the furnace. At Eckardt Hütte, where the ore contains less bitumen, the piles are burned in fifteen days, and the space can be oftener occupied. These slates lose only about eight per cent. of their weight in burning.

2. *Smelting for Raw or First Matte.*—From the roasting piles the slates go directly to the furnaces. They are carried in iron wagons which hold one-third of a ton. They, however, are weighed before being charged into the furnace. The construction of the wagon is different according to the position of the roasting heaps and also the kind of furnace used. For the furnaces which have charging apparatus they tip forward. At Eckardt Hütte they are cup and cone wagons. The wagons are raised to the top of the furnace, when the roasting heaps are below, by a lift. When they are above the top, they are pushed down by men. The furnaces used for smelting ore are of different sizes and types, and vary in number in the different works according to the work to be done. At Krug Hütte there are four; at Koch Hütte there are six; at Eckardt Hütte there are five; and at Kupferkammer Hütte there are three; or 18 shaft furnaces in all. These furnaces are shown in Figs. 2, 3 and 4. They are of two kinds. In one of them, the hearth is entirely interior, where the separation of the matte and the slag takes place by the difference in gravity between the two, in the furnace itself. The slag discharge, which is 0.60 m. above the hearth, allows the melted slag to flow continuously, while the matte collects until it is so near the level of the slag that if it is allowed to rise any higher, the slag will be likely to contain grains of it. The matte is cast through a tap-hole on a level with the bottom of the crucible into conical vessels, where the grains of matte which may have been carried off by the slag will have a chance to settle. These furnaces, Fig. 2, are in use at Krug Hütte and at Kupferkammer Hütte. In the second kind of furnaces there is no interior hearth. The slag and the matte flow out together to the fore-hearth, as in the works at Koch Hütte, Fig. 3, and Eckardt Hütte, Fig. 4, and also formerly in the works at Sangerhausen which are now abandoned. The slag flows continuously from the fore-hearth, but is caught in a series of conical vessels in order to give any grains of matte carried off in it time to settle. The matte is cast in thin plates on cast-iron floors, so that it can,

when cool, be broken up. The shape and height of the furnaces is also different, which is owing to the constitution of the ores. Those

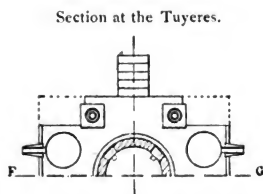
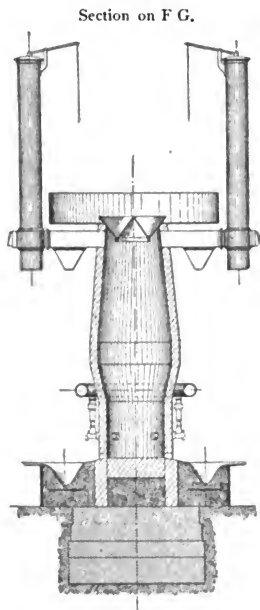
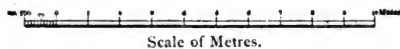


FIG. 3.—Koch Hütte Furnaces.



where high furnaces are used, as at Krug Hütte, contain but little

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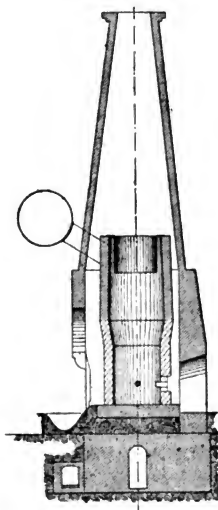
iron, so that they can use hot blast without danger of sows, while at Eckardt Hütte, lower furnaces and cold blast must be used on account of the danger of forming them. The presence of much zinc in the ores also requires lower furnaces. The furnaces with no fore-hearth require a higher pressure of blast. They often, when working at their full capacity, treat as much as 160 tons of ore a day, but as their reducing action is at a maximum, they produce iron sows which retain some copper and make the working of the furnace difficult. Those with interior hearth, in which the whole contents of the furnace is discharged into a receptacle entirely outside of the furnace, require a less pressure of blast, but they cannot treat more than 100 tons of ore a day. This diminution in production is more than compensated for by the fact that all the metallic iron produced passes with the other contents of the furnace into the fore-hearth and consequently no "loups" or "sows" are formed in the furnace. The charging apparatus at Krug Hütte, Fig. 2, and Koch Hütte, Fig. 3, is the cup and cone, which is moved by a crank by hand. The crane has one large wheel with a small pinion. The cone is so arranged that it can be either raised or lowered. At Kupferkammer Hütte, Langen's charging apparatus is used. At Eckardt Hütte, Fig. 4, the throat is entirely open and a cup and cone wagon is used. To avoid any danger which might arise from this disposition, the front of the throat is closed by an iron grating, which opens automatically when the charging wagon approaches it, and is closed in the same way when it is withdrawn. By these arrangements the charge can be made just where the working of the furnace requires it to be. Generally, the ore is charged against the sides and the coke in the middle. When mechanical chargers are used, care is taken to close the joints of the cup and the cone, as soon as a charge has been made, with fine ore and to cover over the charge after it has been put into the hopper with wooden covers.

The blast for these furnaces is produced by either steam or water-engines. These last were largely used at first, but are now abandoned, except at Eckardt Hütte. The steam-engines are arranged as shown below :

	No.	Horse power.	Cub. m. of wind per minute.	Pressure of water.
Krug Hütte, . . .	4	300	700	1.5 m.
Koch Hütte, . . .	2	80	350	1.0
Eckardt Hütte, . . .	2	40	180	0.6
Kupferkammer Hütte, . . .	2	40	180	1.0

In addition to these, there are at Eckardt Hütte, two screw machines (Cagniardelles), which are run by water-wheels when there

Section on A B.



Section at the Tuyeres.

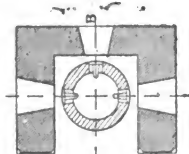
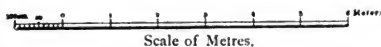


FIG. 4.—Eckardt Hütte Furnaces.



is sufficient water to use them. The quantity of blast, as well as
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its pressure, is regulated by the needs of the furnace. The amount consumed per ton is :

Krug Hütte,	183 Cb. M.
Kupferkammer Hütte,	108 "
Eckardt Hütte,	88 "
Koch Hütte,	121 "

At Krug Hütte, the blast is heated by two pistol-pipe ovens to 200° to 300° C., but this serves for two furnaces only. One was out of blast and one was run with cold air. There was not combustible gas enough to furnish the boilers and heat the air for all the furnaces at the same time. At Kupferkammer Hütte the blast is heated also in pistol-pipe ovens to 125° to 130° C. or even 150° C., depending upon the quantity of combustible gas given off. At the other furnaces the blast is cold, but the gases at Koch Hütte are taken off and burned under the boilers. At Krug Hütte there are two spherical regulators about six metres in diameter and in addition, a conduit pipe, the length of the furnace-house, and one metre in diameter. Generally, there are no special regulators, the blast conduit pipe being sufficiently long and large to serve for that purpose. The tuyeres are of copper and water cooled. The number of tuyeres for each furnace are given below :

Krug Hütte,	6
Koch Hütte,	4
Eckardt Hütte,	3
Kupferkammer Hütte,	7

The number of tuyeres depends upon the quantity of blast to be delivered to each furnace. As the slates usually contain all the material required for making a fusible slag, nothing but materials containing copper, which are rich slags containing grains of matte which come from the different furnaces, are added. Occasionally, when the ore contains an excess of silica the very basic slates from the mine roof are used. Formerly, fluorspar was used as a flux and gave a blue, brittle slag, which cooled quickly and was not suitable for the manufacture of slag—stone or bricks. It is no longer used except when the slag becomes pasty and the tuyeres are dark, and then only to cure the difficulty. The fuel used is exclusively coke from Westphalia, which has only five per cent. of ash. It is quite strong and from 125 to 200 kilos per ton

of ore is used, according to its fusibility. The average for 1889 was 185. The temperature of the gases escaping from the top of the furnace is from 100° to 300° C. They are carried into dust chambers of masonry through cast-iron pipes. The dust collected there is made into bricks and burned with the ore. After passing the dust-chambers the gases at Eckardt Hütte escape into the air. At the other furnaces they serve either to heat the boilers or the air or both, in order to make use of the carbonic oxide which they contain, the quantity depending on the greater or less quantity of fuel used.

The analyses of these gases is given below:

	Krug Hütte.		Koch Hütte.	Eckardt Hütte.	Kupferkammer Hütte.	
	1881.	1888.	1888.	1888.	1881.	1888.
Carbonic acid, .	10.8	9.3	11.1	13.6	15.0	15.5
Carbonic oxide,	16.8	18.8	20.6	15.2	14.0	12.8
Oxygen, . . .	0.4	. . .	. . .	. . .	0.1	. . .
Nitrogen, . . .	72.0	71.9	68.3	71.2	70.9	71.7
	100.0	100.0	100.0	100.0	100.0	100.0

Furnaces with interior hearths are used at Krug Hütte and Kupferkammer Hütte. At Krug Hütte there are four, Fig. 2; at Kupferkammer Hütte there are three. One of these is being rebuilt on the model of those used at Koch Hütte, Fig. 3. It is probable that one other will be remodeled in the same way. The arrangement of these furnaces differs but little. At Krug Hütte the fore-hearth is made of two cast-iron vessels in the shape of truncated cones set on the largest base. They are 0.75 m. on the bottom and 0.60 m. on the top, and are 0.75 m. high. On the bottom of each is an opening, which below is 0.15 m. long and 0.20 m. high and 0.25 m. wide. There are two of these vessels set facing each other on the platform of a cast-iron car with four wheels, so that the openings face each other and form when connected a canal communicating with both. The joints are luted with clay. As the top of the wagon projects considerably over the wheels, it would, while moving away from the furnace and being manipulated afterwards, be in a state of unstable equilibrium, so that a set of

V-openings are cast on the under side, into which temporary feet are placed while it is being manipulated or when it is drawn away from the furnace, to prevent its tipping over. There are also places cast in the same way on the bottom to receive the handles with which the wagon is shoved when it is moved. These are inserted and the wagon pushed. The first one of the conical pots is slightly lower than the one next the furnace, and has two cast-iron spouts bolted on to it at the top, one in the direction of the long axis of the wagon and the other at right angles to it, about 0.20 m. wide, 0.25 m. long and 0.20 m. deep. They are used alternately when it is necessary to change the overflow slag pots when one is full and an empty one is to be placed to receive the slag. On one side at the bottom is a hole, for tapping the matte, which is collected at the end of the run. The slag flows from the furnace into the first vessel and through the opening in the bottom into the second, and from there through one or the other of the spouts into the ordinary slag wagon on wheels, and from the slag collected in these the matte knobs are broken when the slag is cold. The slag is pasty, but is poor and can be thrown away. At the time of casting the matte, which is done every eight hours, this fore-hearth is removed. When it has become sufficiently cool, the slag and matte from the inside is tapped out at the bottom. This is collected in a conical pot. The knobs are broken from it, but all this slag is sufficiently rich to be retreated, and goes back into the furnace after the interior has been tapped out. The two cast-iron pots together are lifted off the platform of the wagon by a crane and held for some time in suspension. The slag which is cooled on the outside, is a casting the shape of the inside of the pots and remains on the platform. During this manipulation the temporary feet are placed under the wagon. After a little time, when it is solid, the slag is pried off of the platform of the wagon, and is thrown to the ground, and in about twelve hours is picked over. When all the slag is off, the platform is covered with sand or ashes, the top placed on it, and it is ready for use again. The fore-hearth is made over in this way every eight hours.

At Kupferkammer Hütte and Koch Hütte the details of removing the slag are somewhat different, although the principle is the same. The slag runs from the furnace into a conical cast-iron pot on wheels, 1.30 m. in diameter and 1 m. deep, which, when the matte has been cast, takes about fifteen minutes to fill. While it is filling,

the spout is dammed with ashes, and when it is full the top is also covered with ashes. The dam in the spout is removed and the slag flows over into a receiver. This receiver is made of two wagons, the cast-iron tops of which are covered with cast-iron boxes having sloping sides. They are the ordinary slag wagons of the works. They are 1 m. long, 0.75 m. wide below, and 0.75 m. long, and 0.55 m. wide above, and 0.75 high. These wagons are keyed together so as to be perfectly firm. On the lower part of these boxes there is an opening 0.30 m. wide and 0.25 m. high on the facing sides of the two wagons. This is covered over by a piece of iron bent twice at right angles so as to form three sides, which are firmly clamped after being hammered to place. On the outside of the wagon two spouts at right angles to each other are placed, one being dammed while the other is running, and under these the ordinary slag-pot is placed. All the joints in the two wagons are closed with clay, and ashes are thrown over the bottom to prevent the slag from sticking. The conical pot and wagons have openings in them at the side at about half their height. The one in the conical pot next the furnace is closed with clay, those in the wagons with a plate of iron placed over it and held in place by a rod, against which a wedge is adjusted for the purpose. The object of these holes is to tap off the upper part of the slag in each when they are removed just before casting the matte. This slag is poor enough to be thrown away. The slag below is rich and must be saved. The conical pot in front of the furnace and the wagons are entirely independent the one of the other. When the conical pot is half full ashes are thrown on the surface to prevent loss of heat. This cover is increased little by little until the pot is full. The wagons are treated in the same way. When they are full the overflow runs into an ordinary slag wagon.

At the time of casting the matte, everything is removed from the front of the furnace, the poor slag on top of the conical pot and the wagons is tapped off, and the wagons carried to the crane to have their sides removed. The conical pot is turned over and the rich cone of matte below broken off. All of the slag remaining in both pot and wagons is broken up and goes through the furnace. At some of the furnaces these pots are round, cast in two pieces, and the conical pot is the overflow. No special difference is found in the working of the two. If any difference is found it is in favor of the round on account of the simplicity of the cast-

ing. On the other hand it must be said that there must always be a number of extra slag wagons on hand, and that this disposition reduces the number of castings required for the works.

When the crucible of the furnace is full, which is every eight hours, the matte is cast by a runner into a bed, the bottom of which is made of cast-iron plates and the sides of a dam 0.15 m. high. These beds are from 5 to 6 m. square, their size depending on the space which can be utilized near the furnace. The matte is cast through a runner made of cast or wrought iron lined with clay. To prevent the matte from spattering and to make it run evenly, at Kupferkammer Hütte, two rings of cast-iron, 0.50 m. in diameter, one above the other, are placed at the end of the trough which serves to spread the matte. The matte contains 30 per cent. to 50 per cent. of copper. The ordinary run is 12 tons of matte, but 18 tons are sometimes made. In the old style of furnace at these works, as much as 150 to 160 tons of ore and slag were put through the furnace, but, in the new one being built, not more than 100 tons can be treated, the object of which is not to charge any more of the rich slags from the matte concentration, which, in the near future, will be smelted by themselves. The old furnaces have seven tuyeres; the new ones only four. They have frequently to be rodded. Once a week, in these works, the whole charge of the furnace is run out into a basin in front and the hearth cleaned. The matte is cast from this receptacle. The slags are very rich and are put back into the furnace. Generally, much zinc oxide and fumes of sulphuric acid are given off during the time of casting and from the matte bed. When it is cool, the matte is covered with sulphur, which continues liquid long after the matte is black. While the casting is going on, after the matte is in the bed, as many as twelve assay samples are taken in a little iron spoon attached to a long handle. These are cooled in water and are collected in an iron box. Many samples of the slags are taken just before casting by plunging an iron rod into them, which is immediately cooled in water. When all the matte is out of the furnace and the slag commences to run, the end of the casting trough is closed. The slag and matte which collect in it are separated when cold. After every fifth casting at Krug Hütte, the whole contents of the crucible of the furnace is allowed to flow into a conical receptacle made at the sides of the furnace, which is lined with brasque and which is 1.20 m. in diameter and 1 m.

deep, in order to effect a liquation and to get rid of the sows which commence to form. The bottom of this basin is divided into three parts by slag blocks to make the separation of the sows easier. When the basin is full, it is covered with ashes to keep in the heat and allowed to remain for six hours. The matte is then tapped from top. The contents of the basin separate into two distinct parts. The bottom is an iron sow containing copper and very rich in nickel, and is sold to England. The upper part is matte, which is cast as usual. The tap-hole is opened with an iron point, which is driven in with sledges. When it cannot be easily withdrawn, a yoke is attached to the end and it is driven out with sledges. When the tap-hole has been eaten out, so that it is no longer round, it is filled up with clay. This is done by pressing the clay around a stick the size that the tap-hole ought to be. This is driven in tight up to the level of the ordinary tap-hole opening. The front is stopped with clay as usual. The stick burns out and leaves the tap-hole the usual size. The tuyeres need constant rodding.

The furnaces at Koch Hütte and Eckardt Hütte, Figs. 3 and 4, are quite similar in construction, those at Eckardt Hütte being lower and worked with an open throat, while those at Koch Hütte are much higher and are charged with a cup and cone. At Koch Hütte there are six furnaces arranged in a line. The furnaces have an iron mantel, which is 1.20 m. above the tuyeres. This mantel is 1.50 m. high. The wind regulator is a conduit, 2 m. in diameter, which is supported in front of the furnace by hangers from the roof. The gases are taken from the throat and burned under the boilers, but the furnace is run with cold air. Each furnace has a dust chamber, 2 m. square and 5 m. high. The dust is mixed with fine ore made into bricks and burned in the piles. The slag is made into bricks in a yard back of and on a level with the bottom of the furnaces. The bottom of the furnace is 1 m. above the ground and is surrounded by a set of cast-iron plates. The top of it is reached by steps. Between these walls are the conical pots into which the contents of the furnace, slag and matte together, flow continuously. These pots are lined with brasque. The overflow from these fore-hearths runs into slag wagons constructed on the same principle as at Krug Hütte, but differently arranged as already described. The furnace is tapped every eight hours into each one of these basins alternately, and from there tapped into the casting beds, which are paved with cast-iron and

are at the corners of the furnace. When, after eight hours' continuous discharge of the contents of the furnace into the reception basins, the matte is to be cast, the fore-hearth is taken away. The crust on the top of the conical basin is broken off and a rod run through the tap-hole from the inside of the matte basins. In order to keep the matte from spattering as it runs out, an iron ring, 0.25 m., covered with clay, is placed at the end of the trough and in this way the matte is distributed over the entire surface of the casting-bed. Some of the slag runs out with the matte and this is easily removed with an iron tool and is immediately put back into the furnace. During the casting or after it, while the matte is still liquid on the casting floor, six assays are taken with a spoon from different parts of the matte bed. When the tapping is finished, the tap-hole is plugged, the men doing it, being protected with an iron screen. At Eckardt Hütte, there are five furnaces, one of which is used for smelting the dust bricks containing lead. Compared with the other furnaces, they are very small, being only $5\frac{1}{2}$ m. in height and 1.35 m. at the hearth. They have only three tuyères. They are charged with a cup and cone wagon, which makes the charge into a hopper set in the top of the furnace. The entrance to the throat is closed with an iron door which opens automatically. The gas outlet is near the top. The pipe runs up and then back into a large cylinder in front of the furnace. The dust collected in it is settled in hoppers and discharged from them by pipes with slide valves. The matte is cast into a conical cast-iron vessel. The slags are very liquid and run easily, so that only one conical overflow pot is used. They are very poor, containing not over 0.2 per cent. of copper. In twenty-four hours, 95 tons are treated. The coke used is 3 per cent. of the charge.

The reactions which take place in these furnaces are very simple. The slates, having been previously calcined, contain very little foreign matter which can be driven off by heat, but what little there is goes off with the gas. By the time the middle of the furnace is reached the temperature is high enough to decompose the sulphates which have been formed during the roasting, and to drive off any carbonic acid which has remained in the slates. The oxides are reduced in contact with the coke and the carbonic oxide, and as there is an excess of sulphur, become sulphides. When it comes down to the hearth, the heat is high enough to

melt the charge. The silica attacks the unreduced oxides and earths and forms silicates, which melt. The reduced metals combine with sulphur and melt into a matte, which, being of much greater gravity than the silicates, separate from them in the crucible, but, as the sulphur is always in excess, part of it is volatilized and forms, with the reduced zinc, deposits of sulphide of zinc in the upper part of the furnace. Part of the reduced zinc passes into the air and is oxidized and deposits in part in dust chambers or is carried into the air. Some of the zinc passes into the mattes and part is oxidized while the contents of the crucible are discharged in tapping. A considerable amount of dust carried off by the gases collects in the dust chambers. When this contains sufficient copper it is mixed with the fine ore and made into bricks, which are roasted with the ore. At Kupferkammer Hütte the dust collected from these chambers contains considerable quantities of lead. This is sent to Eckardt Hütte to be treated for lead, with the dust which is collected there, which contains ten per cent. of lead and two per cent. of copper. Not more than 50 per cent. of this material is collected at Eckardt Hütte, as the furnace runs with an open throat. The lead which is contained in the dust is divided as follows :

Regained,	50.1 per cent.
In the matte,	15.4 "
In the scoria,	25. "
Volatilized and lost,	9.5 "
	<hr/>
	100 "

The furnace in which this dust is treated is blown with the Cagniardelles, which work very slowly but give plenty of pressure. Besides the shaft furnaces for matte, there is in the same building at Eckardt Hütte one small furnace for the treatment of dross and one for the treatment of the concentrated matte slags. The quantity of ore treated per day in each of these furnaces is given below :

Krug Hütte,	136 tons.
Koch Hütte,	101 "
Kupferkammer Hütte,	134 "
Eckardt Hütte,	80 "

As the result of the fusion, several substances are produced. The most important one of these is matte. There are produced besides, the slag and a small quantity of iron sows and of attachment to the furnaces, such as cadmia. The sows contain a very

large number of substances. These are iron, manganese, cobalt, nickel, zinc, arsenic, molybdenum, vanadium, copper, silver, sulphur, carbon, phosphorus and silicon. The cadmia are made up of zinc oxides and sulphides, which contain some unmelted slates and coke dust. The mattes are of a blueish, iron-gray color, and correspond to the blue mattes or regulus of the English process. It varies somewhat in composition with the ores. It has a specific gravity of 4.7 to 4.8. Those from Kupferkammer Hütte, where the zinc is in large quantity, contain whitish streaks. These run from 30 to 50 per cent. of copper, and from 0.1 to 0.8 per cent of silver, with more or less large quantities of iron manganese, cobalt, nickel, zinc and lead. The quantity of sulphur they contain is usually 23 to 27 per cent. If the mattes are cooled rapidly in thin sheets they are quite compact, but when they cool slowly and in large masses they contain bubble-holes filled with moss copper. When cast in thin plates the copper does not have time to separate, but when cast in conical pots, where the cooling takes place from the outside in, and slowly, the separation always takes place, especially where the mattes contain from 40 to 50 per cent. of copper. When they are richer or poorer it is not so apt to form. The moss always forms in the bubble-holes produced by the evolution of gas, and when the cooling takes place rapidly these do not have time to form. The composition of the matte is very nearly $\text{Cu}_2\text{S} + \text{Fe}_2\text{S}$. When the separation takes place, the reaction is, according to Scheerer, $\text{Cu}_2\text{S} + \text{Fe}_2\text{S} = \text{Cu}_2 + 2 \text{FeS}$. The matte is rarely crystallized, and when it is, it is a combination of the octahedron and cube.

The quantity of ore treated in 1889 was 502,750 tons, which yielded 39,588.4 tons of matte. Of this amount,

Krug Hütte,	treated, 132,150
Koch Hütte,	" 150,000
Eckardt Hütte,	" 116,000
Kupferkammer Hütte,	" 104,600
	<hr/> 502,750

The yield of the ore, deducting the rich slags and furnace residues which have been added to the charge, was, in 1889, 3.292 per cent. of copper and 0.0194 per cent. of silver or six ounces to the ton. The quantity of matte produced was 8.47 per cent. of the ore treated. It varies from year to year from 4 to 9 per cent., according to the richness of the ore. The matte is sent at once

to the Kupferkammer Hütte and Eckardt Hütte to be roasted and concentrated. The composition of the matte is given in the table below :

	Kupferkammer Hütte.			Krug Hütte.			Eckardt Hütte.			Koch Hütte.		
Iron,	26.6	21.56	27.54	2.0	24.325	20.53	25.9	21.867	26.24	23.778	20.970	21.48
Manganese,		0.648			0.85			0.533			1.080	
Nickel,	0.59	0.398	0.49	0.35	0.3	0.36	0.485	0.327	0.47	0.486	0.205	0.49
Cobalt,	0.180	0.366	0.12	0.01	0.292	0.03	0.05	0.283	0.04	0.416	0.141	0.13
Arsenic,		0.13			0.08			0.106			0.086	
Zinc,	9.149	7.02	8.73	4.57	3.711	4.48	5.55	2.867	5.87	3.012	2.412	3.01
Lead,	1.210	0.60	1.06	0.69	0.537	0.75	1.046	0.745	1.13	0.643	0.675	0.75
Copper,	30.5	39.06	31.64	44.9	41.36	43.80	36.4	46.30	37.36	44.815	44.5	43.83
Silver,	0.152	0.240	0.156	0.23	0.226	0.21	0.18	0.266	0.17	0.255	0.225	0.26
Sulphur,		26.229	27.50		25.815	25.5		24.401	26.0		25.368	26.70

The slag is composed of the materials which are not reduced by the carbon. They are singulo-silicates of alumina mixed with singulo- and bi-silicates, earths and metallic oxides, and contain besides the oxides of the partly oxidized metals. Tri-silicates are very seldom found. They have a density varying from 2.5 to 3. The following are the analyses of the slags made for the most part in 1888:

	Krug Hütte.	Koch Hütte.	Eck'dt Hütte.	Kupferkammer Hütte.				Sangerhausen Hütte.	
	1888.	1888.	1888.	1881.			1888.	1881.	
Lime,.....	18.35	23.187	21.510	19.29	20.29	19.50	19.15	33.10	23.40
Magnesia,.....	6.732	2.22	0.847	3.23	4.37	8.02	3.677	1.67	0.87
Alumina,	14.825	17.001	16.525	16.35	15.67	18.17	17.616	4.43	7.83
Iron Oxide,.....	4.725	4.643	2.768	10.75	8.73	5.89	7.213	4.37	7.47
Manganese Oxide,.....	0.697	0.328	0.744	.....	.....	.....	0.827	.....	.....
Nickel and Cobalt Oxide,...	0.063	Trace.	Trace.	.....	.....	.....	0.038	.....	.....
Zinc Oxide,.....	1.165	0.692	0.934	1.26	1.11	3.57	2.056	.....	.....
Lead Oxide,.....	0.232	0.118	Trace.	.....	.....	.....	0.065	.....	.....
Copper Oxide,.....	0.289	0.277	0.3	0.75	0.67	0.23	0.333	0.25	0.30
Silica,.....	47.63	48.465	46.39	48.22	50.0	48.38	46.81	53.83	57.43
Fluor, .....	.....	.....	.....	.....	.....	0.99	.....	2.09	1.97
Total,.....	94.708	96.931	90.018	99.85	100.84	99.75	97.802	99.74	99.27

The slags in the normal working of the furnace run thin. This is necessary in order to allow of as complete a separation of the matte from it, in the crucible of the furnace as possible, and to make sure that any grains of it carried off into the fore-hearth will settle there. There is but little loss of copper from this cause. Most of it is from the formation of copper oxide, which combines with the silica of the slag. All attempts to prevent this entirely have failed, though, from the constant attention paid to it, the slags do not usually contain more than from two-tenths to three-tenths of copper. They are the poorest copper slags known. When these slags are cooled as they run from the furnace, they are glossy and dark-colored and look like obsidian, and in such a condition they are sent to the dump-heaps. When, however, they are made to cool very slowly, they appear clear, and they become gray and crystalline, so hard that they strike fire with a steel. In such a condition they can be used in construction. As the weight of the slag is very nearly that of the ore charged in the furnace, and the amount is over 400,000 tons annually, they would occupy, if thrown away, so large a space that they would be a serious source of expense, for which reason they are now moulded into shape and sold for paving and building stone. In order to accomplish this, the slag, after passing the fore-hearth, is made to flow into cast-iron wagons with flaring sides, which are easily movable. These wagons resemble in every particular the cars used to transport slags from iron blast-furnaces. The ends of the tops of these slag-cars are cast in one piece and are reinforced by ribs cast on the outside and by two wrought-iron bands, 0.005 m. wide and 0.004 m. thick, which are riveted on between the top and the bottom. The sides are made of two pieces bolted together; the sides and ends are securely fastened together so that they form a rigid box, larger at the bottom than the top. At each of the corners there is a ring for the attachment of hooks and chains, by which the box may be lifted off or placed on the wagon. The cast-iron platform of the wagon is supported by four wheels. It is 1.10 m. long and 0.80 m. wide. The box is only a little smaller than the platform and is fitted on to it by steps, which make it go to its place but do not prevent its being moved on the platform when necessary. The top of the box is 0.85 long and 0.55 m. wide and 0.45 m. high.

When the slag-wagons come from the furnace full they are

carried to an area of variable size, which at Krug Hütte is 150 m. square, to be made into bricks. At this furnace the yard is made on the top of an old slag-heap. The bricks are of all kinds of shapes. They are made on a sand-bed. The sand is first dug out to the required depth. A man with a rake with tines 0.10 m. long rakes over the sand and shovels it up into a sieve made of hexagonal holes 0.03 m. across. This is sieved, and whatever remains upon the sieve is thrown to one side. The frame of the sieve is 0.60 x 0.40 m. All that remains on the sieve is thrown into a car to be carried away. The bottom of the bed is then carefully gone over with a shovel, pressing the shovel in several centimetres to make the sand soft. It is then smoothed over with the shovel, and into the corners a piece of iron, 0.18 m. to 0.20 m. long, 0.15 m. wide is laid, laying it inclined to facilitate the passage of the slag in the slag-runners which go around the whole space. Iron partitions, 0.70 m. long and 0.20 m. wide, are then placed in the sand and pushed down into it. To hold the first one a vertical piece is put back of it to support it. These long iron pieces have round holes in them, usually four, which are 0.05 m. in diameter. They have previously been washed with clay and sprinkled with sand to prevent the slag from sticking to them. When the first one is in, the next is put up in the sand in the same way and the end pieces put in; each short piece has ears fitting into places cut out of the long ones. The frame work is set up in this way until the requisite number of divisions have been made. In each of the places usually two beds of twenty-eight divisions are made, four wide and seven long. Around and between each a space 0.20 m. wide is left for the slag to circulate. When the blocks to be cast are to be used for ordinary pavements, which are somewhat larger at the top than at the bottom, and which also when laid need a space between them at the top for the hoofs of the horses to catch in, a small piece of iron is placed on each side at the bottom to make a depression. When the whole of the wrought-iron partitions are in place, the bottom of each division is made flat by placing in it a piece of sheet-iron attached to a handle of exactly the size of the compartment and stamping it down. To be quite sure that the irons of the partitions are quite in their places, both on the long and on the short sides, a small hammer 0.03 m. square and 0.08 m. long is used for tapping them. The end sections are put in first and then the middle ones, after several

long plates have been stood upright. The long divisions have holes in them; the middle ones may or may not have them. There is a great discretion to be used with regard to the putting up of these plates and the direction to be given to the liquid slag, which is regulated by the position of the holes, for the exact direction of the flow of the slag seems to make a very great difference in the solidity of the blocks. Generally the three rows nearest the point where the slag flows in do not have any holes on the sides, but only at the ends. The man who sets them up uses his discretion as to how the holes are to be placed. They do not always make the paving blocks of the same size. The width remaining the same the length is varied.

When the bed is ready the men with the slag-wagons come. The wagons are brought opposite to the casting bed, and one corner of the box on the top of the wagon is pried off of the platform over the runners for the slag; this throws the chilled bottom of the slag in the wagon outside of the platform. With a pointed hammer a hole is made in the bottom of the slag, which is enlarged a little and the slag flows into the runners and from them into the moulds. When it is about half way up towards the top of the mould, a little sand is thrown over it to prevent its cooling too rapidly. By the time all the moulds are entirely full, the whole of the runners and all the slag are covered about 0.03 m. deep with sand and left for forty-eight hours. As soon as the slag no longer runs from the wagon the cast-iron cover is turned back on to the platform of the wagon leaving only a hollow crust of slag in the interior, and the wagon is carried away to the place where the cover is lifted off and the slag is prepared for being thrown away. When it rains hard and the weather is not propitious, boards are used to cover the casting-beds before they are filled with slag, so as to prevent the water getting into them, which would make the slag-castings porous, and afterwards over the sand with which they are covered to prevent too rapid cooling. When the stone is cool the sand is shoveled off and the iron partitions are lifted out and thrown to one side. This leaves the blocks in the bed with a space between each. An inspector comes and taps each block with a hammer. If they are not solid, he breaks the defective parts off with the hammer and picks them out with a square tongs the size of the stone. If, when broken, they are too thin, he throws them away. If not, they are made into a third quality stone, which is dressed

to be used in the gutters of the streets or anywhere where thin stones are required. Those which are not defective are lifted out and turned over. If they are exactly square they are first quality. If not, of second. The seconds are just as good as the first quality except for being a little out of square. The stones so sorted are carried to the dressing floor, where they are dressed up, the sharp corners being beaten off and the projections corresponding to the holes in the iron divisions beaten down. Generally the small sizes are made at Krug Hütte, but pieces 0.30 m. square are also made there. The material from the runners is used for making the roads and for mosaic pavements, for which it is very suitable. When the casting place is cleared of slag-blocks, the irons which are lying on the sides are taken up by a man who comes with a pail filled with clay water. The small ones are put into this pail in bundles, and when taken out they are separated slightly and a man with a riddle 0.20 m. square and 0.10 m. deep made of sheet-iron with 0.003 m. holes riddles sand over them. The long pieces are put into a trough and treated in the same way, but each piece is sprinkled with the sand separately. The stones are generally 0.15 m. cube. Those 0.23 m. by 0.23 m. and 0.46 m. are also made and even larger ones. When three rows instead of four are made in the casting-bed, the end ones are made short and the middle ones a size and a half larger.

The wagons from which the slag has been cast are brought by horses back in front of the furnace-house, to have the sides lifted and the slag removed. Two cranes are provided for this purpose. They are arranged in the form of an arch over a double track, and have both a horizontal and a vertical movement. As soon as the cover is lifted the car is shoved forward and the cover immediately placed on another wagon, which is drawn on the track on the opposite side, and is at once taken away for use and another slag-wagon and platform drawn under the crane. When no platform is ready, the cover is left suspended until there is one. As soon as the top is lifted off from the platform a sheet-iron rim 0.12 m. high is placed on the platform of the wagon around the slag crust. The wagon is then drawn forward. When four of the cast-iron rims have been lifted off, the crusts are cold enough to break upon the outside. With a wooden pole, 0.08 m. in diameter and 2 m. long, one side is broken in, and in five minutes after the other side; then the top and the ends. Most of the pieces

fall within the rim and make a low pile on the platform of the wagon. A few pieces fall outside on to the track, and these are from time to time taken up and thrown on to the wagon inside the rim. When the slag on eight wagons is broken up in this way they are drawn away to the slag-dump, and when four wagons have the cast-iron tops replaced upon them they are washed on the inside with clay, and are drawn by a mule to the furnaces where they are to be used again.

The whole casting space is covered over with tracks laid down temporarily. These are laid in sections 3 m. in length. Whenever it is convenient, turn-tables made of plates of cast-iron and fixed, are used to go from one section of the casting-ground to another. The moulds are prepared by one man, the irons by one man, the casting by one man, and each slag-wagon has one man. Of the slag, one-third is already solidified on the sides. Of the two-thirds left, two-thirds are made into stone and the rest is in the runners. Of the twenty-eight blocks made for small-sized paving stones, twenty are generally of first quality, five to six of second, and the rest third. The first or second quality depends entirely upon how carefully the iron plates are put in. The slag in the blocks is gray and compact and when laid in mosaic looks very much like a compact limestone.

The manufacture of slag at Koch Hütte is done in the same way as at Krug Hütte. For large blocks, the moulds are made of cast-iron with a cover with a long handle, which shuts down so as to compress the slag. The cover has holes in it in order to prick the slag and let out the gas. Ashes are also used as a cover. Very large stones are made here, such as steps for stairs and stones of any kind for building purposes. The work is done only at night and with the extra men, who are always kept at the works, when they have nothing else to do. Only paving-stones of second quality are attempted to be made. They are made of any size required. Only the crust is usually lost. The rest of the material is used for roads. Slag bricks are also made at Kupferkammer Hütte, but the work is much less skilfully done. For large-sized stones, irons bent at right angles are used. As they are not covered with clay they deteriorate rapidly, and the stones made are very coarse. In 1889, about 4,400,000 articles were made at all the works, out of slag. Of these, 210,826 were made into pieces used in construction, 4,163,655 into paving-stones, borders and slabs,

and, in addition, 13,381 cubic metres of *débris* from the slag brick manufacture and other slag were used for making roads, all of which were sold. The towns in which the works are situated, and all their environs, as well as all the roads leading to them, are paved with this material, and it has proved to be better and cheaper than stone.

(To be continued.)

EXAMINATION OF MINES.

By H. S. MUNROE.

(Continued from Vol. XII., p. 27.)

FORMATION OF MINERAL-DEPOSITS.

THE engineer should, of course, be familiar with the literature of ore-deposits, and fitted by practical experience in mining operations and by training in field geology to make an intelligent examination of the deposit. An admirable series of articles * on the literature of ore-deposits has lately appeared in the *QUARTERLY* to which the student may be referred, and which will serve as a guide to a course of reading on the subject.

The engineer should not be too hasty in his generalizations, and should bear in mind that similar deposits may have widely different origin, and even that parts of the same deposit may be due to different causes. Deposits of magnetic-iron in some cases may be altered bog-deposits or metamorphosed beds of carbonate of iron, originally of chemical origin; in other cases they may be purely mechanical deposits concentrated by the action of running streams,† or again in other cases, it is possible that they may have been formed by replacement, or deposited from solution in cavities and fissures. Or part of the deposit may be due to one cause and part to another as at Iron Mountain, Missouri.‡

* "On the Literature of Ore-Deposits," by J. F. Kemp, *SCHOOL OF MINES QUARTERLY*, vol. x., pp. 54, 116, 326; vol. xi., p. 359.

† H. S. M., *SCHOOL OF MINES QUARTERLY*, vol. iii., p. 43.

‡ The "Iron Mountain Mine," Prof. W. B. Potter, *American Institute of Mining Engineers*, New York meeting, September, 1890.

In the examination of a mineral deposit the engineer should be careful to observe and to record his observed facts without bias or prejudice in favor of one theory or another. He should form his conclusions with great care and deliberation. A theory is of value mainly as a means of bringing disconnected facts into some kind of arrangement, so that they can be studied, and is useful only so long and so far as it accounts for the phenomena observed.

In no department of mining engineering is there greater opportunity for brilliant professional success, and in none have failures from hasty and crude generalization proved more disastrous.

MEASUREMENT OF DEPOSITS.

In the case of coal seams and similar deposits, the volume of mineral within the limits of the property may be computed with great accuracy. The areas of coal within the lines of outcrop may be determined by measurements on the map. The surface and underground explorations should give data to estimate what part of this area may be regarded with safety as workable. The average thickness will be obtained from numerous measurements.

A seam of coal of 1.3 specific gravity will contain about one hundred and thirty tons per acre for every inch of thickness. For other densities multiply the specific gravity by one hundred. Allowing for pillars and waste in mining, the common practice of estimating one hundred tons per acre per inch of thickness, approximates very closely to the probable yield.

In irregular coal basins, as in Pennsylvania, the volume of mineral is obtained by developing the warped surfaces graphically and multiplying the areas thus obtained by the average thickness,* or the method suggested by Mr. R. P. Rothwell may be used, and the horizontal area underlaid by coal multiplied by the thickness of the bed or beds measured vertically (instead of normally to floor or roof as above).

MEASUREMENTS OF IRREGULAR DEPOSITS.

Metalliferous deposits as a rule are much less regular in thickness than coal seams. Certain precautions should be taken to

* *Second Geological Survey of Pennsylvania*, Report AA, p. 107. Also "A New Method of Mapping the Coal-fields of Pennsylvania," *Transactions American Institute Mining Engineers*, February, 1881.

secure accurate results. When the variations in thickness are great the prismoidal formula * may sometimes be used with advantage and limited portions of the deposit computed separately. In other cases the average thickness may be used. To obtain this accurately the measurements averaged should be as nearly equidistant as possible, and greater weight should be given to measurements on a mid-section than to those on the boundaries. The determination of the average thickness, and the areas required by the prismoidal formula, will be facilitated by carefully constructed cross-sections of the deposit.

Sometimes the thickness to be considered is modified by special conditions. For example, the vein may be very thin, and yet workable; as is often the case in gold and silver mines, and in rich deposits of the other metals. In such cases the width and height of the workings will be constant and independent of the thickness of the mineral, as enough broken rock will have to be mined to enable the men to enter and work.

In like manner when the ground is traversed by well-defined fissures parallel to the vein, it may be necessary to mine the barren rock up to this fissure in order to make the workings safe.

Again, where the vein or bed is split and the two portions are separated by a "horse" or "parting" too thin to be left standing, it may become necessary to mine this rock with the ore.

In all such cases the mining and handling of this barren material must be taken into consideration, and the necessary measurements made so that its amount and its effect on the average richness of the material mined may be determined.

DETERMINATION OF WORKABLE AREA.

In the case of a uniform and persistent bed, horizontal or slightly inclined, the total workable area may be assumed to be that contained inside the outcrop and within the property lines. If the bed lies at an angle, allowance must be made for the inclination.

In the case of a bed or vein dipping at a high angle we may have another limit, that fixed by the maximum depth at which the mine can be worked with profit.

In the case of less regular deposits, the workable area within the above boundaries, that is, the proportion of this total area that

* See *Trautwine's Pocket Book*, p. 160, and *Treatises on Railroad Surveying*.

can be profitably worked, must be more or less a matter of uncertainty until the workings actually traverse the whole area. This, in most cases, does not occur until the deposit is nearly exhausted and the knowledge is of little practical value.

Sometimes, we can form an estimate of the relative areas of workable and unworkable ground from that portion of the deposit which is exposed by the exploratory workings. A careful study of these developed portions of the mine will often reveal the laws governing the distribution of the useful mineral so that the future may be predicted with some confidence. Estimates thus made may be sufficiently trustworthy to be applied to the undeveloped portions of the mine.

Variations in thickness and in richness or quality of the mineral are often sudden and unexpected. Large barren or unworkable areas are liable to occur, or the deposit may come to an abrupt end. The estimates of mineral in undeveloped portions of the mine and the values deduced therefrom are of necessity speculative. This should be made very clear in the report on the property. The value of an engineer's estimate of the speculative value of the property, as opposed to the wild guesses of interested and over-sanguine parties has been pointed out.

ORE "IN SIGHT."

In the case of very irregular deposits, isolated ore-bodies, lenticular masses, chamber deposits, bonanzas in veins and similar deposits, the continuance of which in depth is uncertain, it is unsafe to estimate on more mineral than that proved to exist by the exploratory workings. Many engineers prefer to take this course in all cases, and estimate the value of the mine from the mineral "in sight." The term mineral "in sight" is variously interpreted by different engineers, but can be defined as the mineral which can be proved to exist, the nature and amount of proof necessary, varying with the character of the deposit.

In most cases, the mineral to be "in sight" should be exposed on at least two sides by workings more or less parallel and not too far apart. For example, the coal between two parallel gangways; the mineral between the uncovered outcrops and an underground level; or the ore between two inclined shafts in the vein.

It is not safe to estimate on mineral exposed on one edge only, as

the edge exposed may chance to lie along the boundary of large unworkable areas.

The workings should not be so far apart as to leave chance for the existence of unworkable ground between.

To lessen the chance of unworkable areas within the body of ore "in sight," many engineers demand that at least three sides shall be exposed by workings. For the same reason it is well to connect the parallel workings by others at right angles, winzes, cross-headings, etc., and thus divide the deposit into rectangular blocks exposed on four edges. This will be a necessary preliminary to working the deposit in any case, and has the added benefit of securing better ventilation of the exploratory workings.

When a portion of the deposit is exposed on two adjacent sides only, e.g., by a shaft and a drift, or by the outcrop and a shaft or a drift, it is customary to estimate as "in sight" the triangular area bounded by the workings in question and a straight line joining the ends of the same.

SAMPLING AND ASSAYS.

The samples required for assay to determine the quality or richness of the mineral should be taken at numerous points, and so taken as to represent the average value of the deposit at each point. When different benches or different zones of the deposit vary in richness or in quality, the samples from such subdivisions may be taken separately at each place.* Different benches of a bed of coal may differ greatly in character, amount of ash, of sulphur, of volatile matter, etc. It is not necessary or desirable, however, to subdivide the samples taken unless the benches can be kept separate in mining.

With the above exceptions, the sample taken at any one place should represent the whole deposit, from foot to hanging-wall.

In coal and soft ores, a uniform groove for this purpose is cut with a pick, or with a hammer and moil, across the face of the deposit.

If the material is harder, one or more blasts may be fired with light charges of explosive, so as to break up and shatter the face without completely dislodging the fragments. Chips and splinters

* See paper by D. H. Browne, "Distribution of Phosphorus in the Ludington Mine," *Trans. Amer. Inst. Mining Engineers*, vol. xvii., p. 616.

may now be broken from the loosened fragments which are still in place, or as they are taken down, so as to give the required average sample.

If the deposit is very wide and uniform, samples may be taken at intervals from foot- to hanging-wall instead of in a continuous groove.

If the mine is being worked, samples should be taken from the mine-cars, from the dumps and stock-piles as a check on the results.

The conditions under which the sample was taken, the manner of taking and the amount of ore represented by the sample should be noted in every case.

"SALTING."

The engineer must use due precaution to detect and guard against fraudulent practices. If a sufficient number of samples be taken underground, and these be taken arbitrarily, and not at points suggested by interested parties, successful "salting" will be made more difficult. Such preparation of the mine is generally on a small scale and at few points. A thorough sampling of the mine makes it necessary to do the work of salting on a large scale. Careful examination of the deposit at the selected points, before taking the samples, will generally detect the fraud.

A more dangerous practice and one more difficult to guard against, is the "salting" of the engineer's samples during the process of sampling or subsequently. Sealed bags and boxes are not always sufficient protection against this form of fraud, as the sample may still be "doctored" with strong solutions of the precious metal.

It is possible again to prepare a mine for examination by concealing the poorer portions of the vein with timbering and loose rock, leaving exposed the richer stopes and headings only, suspending the work in these places when and where the showing is best.

When fraudulent practices are suspected, the engineer should advise the leasing of the mine by the intending purchaser, with privilege of working for six months or a year, in which time the fraud, if any, will be exposed.

EXAMINATION OF PARTLY EXHAUSTED MINES.

A mine that has been worked for a number of years is a less valuable property in exact proportion to the amount of mineral that has been mined. Such a mine, however, has been thoroughly proved, and much of the mining risk attending the development of a new property has been removed. A developed mine, for this reason, usually commands a much higher price in the market, even though a large part of the deposit has been exhausted. The examination of a partly-worked property will be conducted on the lines above laid down for a developed property, with the following additions :

1. An examination and survey of the abandoned workings as far as accessible.
2. A study of the history of the mine, total yield, average richness of the ore, etc.
3. Investigation of details of working, cost and profits.

The survey and examination of the old workings will determine what reserves of rich or low-grade ore exist in the form of pillars. The examination and survey will also show the condition of the abandoned workings and how far the safety of the whole mine may or may not be endangered. If there is danger of a general crush, or if the shafts or main gangways of the mine are threatened, the cost of making the mine secure must be estimated.

Finally, this examination and survey of the old workings will furnish data from which to estimate the total amount of material excavated, which, with the measurement of the waste rock in the dump-heaps and underground, will serve as a check on the statements as to ore treated or shipped and will show what proportion of barren material has to be mined with a given amount of ore.

Finally, the underground survey will show what area has been mined and the proportion of available ground remaining.

It will frequently happen, especially in old mines, that the abandoned workings have caved in, or are inaccessible, so that the survey above outlined cannot be made or can be made only in part. In such cases, the necessary information often can be obtained from existing maps and other sources, and the desired estimates of area, if not of volume, can be made.

The history of the mine, its total yield, the cost and profits of mining, etc., should be obtained by examination of the mine books,

of official reports, the books of transportation companies, of smelting works; and from such other sources as may seem reliable. From this material, it should be possible to obtain the total production of the mine, the average cost and yield per ton, the average selling price and profits; and such other data as will be of service in estimating the value of the mine, and the probable profits of working.

Finally, a careful investigation should be made of the methods of working and of the details of management, that possible improvements, and sources of economy and of increased profits, may be indicated.

EXAMINATION OF ABANDONED MINES.

The reopening and working of abandoned mines is attended with more than ordinary mining risk, and the examination of such properties demands great care and good judgment. The larger and more important the mine, the longer it has been worked, and the more ore it has produced, the greater is the mining risk.

The mine, in any case, is partly worked out, and is by so much the less valuable; and it is possible, and in most cases probable, that the deposit is practically exhausted.

Even in the most favorable cases, the cost of reopening the mine will be very great, and usually will be more than the cost of opening and developing a new deposit. The mine must be drained of water, in itself an expensive operation. The shafts and drifts must be reopened and generally retimbered. As it is quite likely that the pillars and arches have been robbed before the mine was abandoned, much of this work will be through fallen ground and very expensive. Finally, the hoisting-engines, pumps and other machinery will have to be repaired or replaced.

As it is probable that the work of exploration and development was suspended some time before the mine was finally abandoned, so it is probable that much exploratory work will be necessary to prove the existence of valuable mineral.

It is not probable that any part of this expense of reopening will be paid by mineral extracted.

Finally, the working expenses will be greater than in a new mine, especially in the items of drainage, tramming and hoisting, and timbering.

There are cases in which the mines may have been left in more favorable condition, and in which the risk of working will be less.

In countries liable to political disturbances, mines have been abandoned during war-time, and not subsequently reopened. In the western mining regions the ravages of hostile Indians have had a similar result.

Mines are sometimes temporarily abandoned because the conditions were unfavorable to success. Situated in remote regions the cost of the transportation of the necessary supplies and of the products of the mine, may have been too great to allow of profitable working. Or again, on account of the undeveloped character of the region a market for the product may have been lacking, or may have been so remote as to be unavailable. With the construction of railroads and the development of the country, such mines can often be reopened and worked with profit.

Finally, it often happens that mines worked with insufficient capital, or under bad management, are abandoned, and later under more favorable auspices they are reopened and yield large profits.

The examination of an abandoned mine is one of the most difficult problems likely to occur in the practice of the mining engineer.

It is probable that all the available ore has been taken out, and that even the pillars have been robbed before the mine was abandoned. There is no ore "in sight," and little or nothing left to give an idea of the average value of the deposit. Before the closing of the mine it is probable that the advance headings, shafts, drifts, etc., were suspended one by one as the prospects became less favorable. Nothing but poor ground is likely to be found. Finally, the workings are probably under water and inaccessible.

Under such circumstances it will not be advisable to go to the expense of draining the mine until a preliminary examination has been made. In this preliminary examination the engineer must depend almost entirely on the past record of the mine. The evidence, however, is likely to be fragmentary and incomplete, the books in all probability have been lost or destroyed, and but little documentary evidence remains. The engineer will be forced to collect such information as he can from trustworthy sources, and weigh the evidence carefully before submitting an opinion.

Even after the mine is drained a final examination and report

cannot usually be made until the mine is developed to a certain extent by exploratory workings.

In the work of reopening an abandoned mine the greatest care should be taken at each stage of the operations to minimize the mining risk, by limiting the expenditures at any one time to such amounts as the prospects of success seem to warrant. At first the explorations should be in one or two places only; later, if the developments are favorable, a larger force may be employed and the opening of the mine may be pushed more rapidly. Permanent improvements which may be necessary for active work, should not be undertaken until there is sufficient mineral "in sight" to warrant the expenditure.

SCALE OF OPERATIONS.

The proper scale of operations is determined mainly by the size of the deposit, and by the probable life of the mine. In certain cases the market for the product, and the effect of a large production on the selling price, must be taken into account.

The size of the deposit limits the scale of operations chiefly by limiting the number of men and machines that can be profitably employed.

The shape of the deposit also has its influence. For example, a lenticular mass, narrow and thin in proportion to its depth, like a bean pod suspended by one end, cannot be worked continuously on a large scale, as there will be room for but one or two working parties on each level. If worked rapidly one level will be exhausted before the shaft can be sunk to the next.

A regular bed or vein can be worked from several shafts and on several levels at the same time. A large working force can be employed, and the scale of operations will be limited only by the size of the property, and the amount of capital.

The thickness of the deposit limits the working force at each point of attack and the amount of mineral which can be broken at a single blast.

The total value of the deposit, and the probable yearly profit, limit the amount of capital that can be employed (and consequently the scale of mining operations) by determining the amount upon which interest can be paid, and which can be extinguished by a sinking fund during the life of the mine.

The degree of mining risk involved will limit the amount of capital that can be safely invested with any prospect of its being returned to the investor before the mine is exhausted. The uncertainty as to the continuance of a deposit is a maximum in the case of an undeveloped property; so it is especially important to proceed cautiously at the beginning of a mining enterprise, and by working on a small scale at first, limit the amount of capital subject to risk of loss. Later, when the work of exploration has shown a reasonable certainty of several years' supply of mineral, a larger amount of money may be risked, and the work of development pushed more vigorously. In exceptional cases the mine will itself furnish the necessary capital.

With the exceptions and limitations above noted, it may be stated, as a rule, that the scale of operations should be as large as possible, and the mine worked as rapidly as circumstances will permit.

The advantages of rapid work on a large scale are the following:

1. The cost per ton of mineral is less. There are certain fixed expenses, such as pumping, ventilation, superintendence, taxes, office expenses, etc., which are nearly the same whether one ton or one thousand tons be mined per day. Again, it is cheaper to work the plant to its full capacity. For example, in the case of a hoisting plant, the same number of engineers, firemen, bankmen, bottommen, etc., have to be employed whether one hundred tons or one hundred and fifty tons be hoisted.

2. Rapid work decreases the cost of maintaining the shafts, gangways and levels, of renewing timber, of removing falling ground etc.

3. More capital is required for work on a large scale, but the amount does not increase in the same proportion as the output. The capital is redeemed in a shorter time, and the total interest charge is very much less.

NOTES ON THE COAL-FIELDS OF MONTANA.

BY WALTER HARVEY WEED.

(United States Geological Survey.)

A LARGE portion of the 145,000 square miles comprised within the borders of the newly-admitted State of Montana is underlaid by coal-bearing rocks. Through the plains country, that monotonous expanse of arid and treeless land forming the eastern two-thirds of the State, the available coals are all lignites, which occur in great quantity and are often of exceptional purity. The cut-banks of the smaller streams and the bluffs of the rivers very frequently show outcropping coal-seams, and the dark lines can be traced many miles upon the bluffs and buttes of the so-called Bad Lands.

Approaching the mountains, the low relief of the plains is broken by outliers of the Rocky Mountains, and as we near the eastern slope of the ranges, the younger rocks of the plains are found to be upturned against the mountain flanks, and here occur the seams of coal which form the chief source from which Montana's great mining and smelting industries must derive their supply. Unlike the lignites of the plains, these are true bituminous coals, of excellent quality and frequently making exceptionally good coke. These bituminous coals are all older than the lignites and belong to two geological horizons. The coals of Sand Conl  e, Deep Creek and other localities in the vicinity of Great Falls, on the Missouri, have recently been pronounced to be of Kootenay age by Prof. J. S. Newberry, after an examination of the mines and the study of the fossil flora of the locality.* South of the Great Falls field, the Kootenay series appears to be wanting, and the coal-seams of these fields overlie the shales and sandstones of the Colorado group. These seams, from which over half the entire coal product of the State is obtained, were examined by the writer during the past summer, at the Cinnabar and Bozeman fields, and though the study of the coal-fields of the State is therefore just begun, the results are of sufficient interest to present here.

* In a paper presented at the Boston meeting of the National Academy of Sciences, November, 1890.

The relative amounts of coal from the three geological horizons mined in 1889 within the State is as follows:

Lignite (Laramie and Tertiary),	5,263
Later Cretaceous (Lower Laramie),	191,138
Early Cretaceous (Kootenay),	166,480

These amounts will be exceeded for the present year, but the returns will show fully as small a percentage of lignite mined, despite the wide range of this variety of fuel throughout the State, and a nearly equal proportion of bituminous coal from the two geological horizons.

So far as known, the bituminous coals are somewhat limited in their occurrence. The Kootenay coals all come from the vicinity of Great Falls, and the bituminous coals of later age occur only in the following fields: Upper Gallatin Basin, Madison Valley near Virginia City, the Cinnabar coal-field north of the Yellowstone National Park, and the so-called Bozeman coal-field and its probable continuation eastward, the Rocky Fork coal-field. Thus far the last three are the only fields worked, the mines being close to the Northern Pacific Railroad, and the coal in demand at Helena and Butte.

THE CINNABAR COAL-FIELD.

Leaving the deep cañons of the Yellowstone National Park, the Yellowstone river flows through a narrow mountain valley, in which a low mountain, having a bright red streak, is quite conspicuous. This is Cinnabar Mountain, its red streak, enclosed between high, rocky, perpendicular walls, is the Devil's Slide, and though the name of Cinnabar is misleading, it is applied to both the mountain and the coal-field as well.

On the west side of this valley the coal-bearing strata dip at 15° to 20° northwest and form a high and flat-topped mountain ridge extending down from the sharp and rugged summit of Electric Peak, the highest point of the region, in a northerly direction to the knob called Cinnabar Mountain. This block of cretaceous coal-bearing strata lies between an extensive area of volcanic rocks, forming the rugged peaks to the north and west, made up of breccias of volcanic ejectamenta and massive flows of basaltic andesite, and a smaller area of similar rocks to the south, being separated from them by two faults of several thousand feet throw.

On the eastern side of the valley steep granite slopes rise abruptly

from the river, but near the boundary of the National Park a block of coal-bearing strata, faulted against the gneiss, lies between the mountains and the river.

In the upturned beds of Cinnabar Mountain we have a natural section giving the relations of the coal to the older rocks. Resting upon metamorphic strata there is about 4500 feet of massive white and gray limestone of paleozoic age, and above them a varied succession of beds of mesozoic age, the southern part of the mountain being composed of the black shales, with occasional walls of sandstone, of the Colorado group.

A slight break in the sharp, synclinal trough does not obscure the relations of these shale belts to the white sandstones forming a belt some 500 to 600 feet thick that contain the coals. Indeed, elsewhere, we have a conformable sequence showing the coal-bearing sandstones resting immediately upon the muddy limestones and shales.

In this sandstone series there are three workable seams of bituminous coals, besides many seams too thin to work. A section of some 300 feet from the base of the series up, showed eleven seams aggregating twenty-one feet of coal, and the strata above this showed many more small seams. The three workable seams each show from three to six feet of good coal, which meets with a ready sale at \$4.00 to \$5.00 per ton on the cars. The miners are paid \$1.10 per ton, and laborers \$1.75 per day. The oldest and most extensive mine is the "Horr," but the coal lands consist of faulted blocks, and for that reason cannot be so economically worked as in the undisturbed part of the field; the daily output this winter was expected to be 250 tons, and the coke is remarkably fine.

The Craig mine has recently been opened and is now being developed, but has no output as yet. It is the most promising of the three mines, however, as the third, the Bowers mine, is on the east side of the river, where the beds dip at 60° toward a fault that brings the coal measures against the gneiss.

The workings show that the coal varies in thickness in the same seam, and careful prospecting of a seam is necessary to determine whether it will pay to work. The coal varies also in its nature where disturbed; in the Bowers mine it is an excellent coking coal near the surface, but a semi-anthracite at a depth of only 160 feet.

The future of the field all lies in the large block north of Electric

Peak, but the field is too small to warrant any extensive mining operations.

At the Craig workings, the prospecting shows five workable seams. The two upper seams have been opened up by entries of 500 to 1000 feet in length. The upper seam shows 32 inches to 40 inches of clean coal in an entry driven on the disturbed measures, and 4 feet 6 inches in another entry in the less disturbed beds. The analysis of an average sample of the coal shows :

Fixed Carbon,	78.65
Vol. Carbon,	9.65
Moisture,	5.63
Ash,	5.72
Sulphur,	1.35
	<hr/>
	101.00

An entry of 450 feet on the vein below the last, called the B-vein, shows 30 inches to 40 inches of coal from which an average sample gave :

Fixed Carbon,	80.88
Vol. Carbon,	7.42
Moisture,	6.63
Ash,	4.37
Sulphur,	0.70
	<hr/>
	100.00

The C-vein shows 28 inches of coal, the D vein 5 feet, and the lowest of all, the E-vein, 22 inches of coal.

The actual cost of a ton of coal on the dump is \$1 50.

The *Bozeman coal-field*, on the contrary, is extensive enough to predict a favorable future. The coal measures were traced for a distance of over 100 miles last summer while making a geological survey of the region, and if workable throughout this extent, will contribute materially to Montana's wealth. The coal is of the same age as that of the Cinnabar field ; that is, it overlies the great series of cretaceous shales carrying Colorado fossils, and the collections of leaf-remains and unio shells indicate a probable Laramie age, the leaf impressions resembling, as a whole, the collections from the Bitter creek coals of Wyoming.

At Cokedale the coal makes a good coke, but the same seam, worked farther westward, at Timberline and Chestnut, will not coke.

METHODS OF MODERN PETROGRAPHY.

BY H. HENSOLDT.

(School of Mines, Columbia College.)

III.

ROCK-SECTIONS AND HOW TO PREPARE THEM.

(Continued from Vol. XI., p. 35.)

THE cut produced by a well-charged diamond-saw, which runs true and does not wobble, is so smooth and level that only a trifling amount of grinding is necessary for the first surface. For this the writer uses a copper disk, $7\frac{1}{2}$ inches in diameter and about one-half inch thick, which is affixed to a conical steel pin, fitting the spindle of the bench. The very finest grade of washed flour-emery is used for this operation; but if the cut is not a level one or is marked by the grooves or furrows of a wobbling saw, coarser emery may be first employed till all unevennesses are effaced. The copper disk on which the grinding is effected should not have a true level surface, but a *slightly convex* one, for the following very important reason:

When grinding any kind of rock-surface, it will be noticed that the marginal portions of the specimen are always more energetically attacked than the central ones; in other words, the emery—however fine—invariably acts quicker around the margin than in the centre of the specimen. Now, if the grinding-disk or plate is a perfect level, the surface to be ground must, as a matter of course, become more or less spherical, the convexity being determined by the degree of fineness of the emery used. To this seemingly trifling circumstance the failure of most petrographers in producing large and uniformly thin sections, in spite of the utmost care, is due. It must be borne in mind that the convexity, however slight, is repeated on the second surface, so that the section can never be of uniform tenuity, but must always remain thicker in the centre. Such a section can hardly be improved by additional grinding, for whatever is gained in transparency in the centre is lost in substance around the margin; the section always retains its lenticular

curve and becomes less and less in diameter as the grinding proceeds.

In order to counteract this peculiar tendency of the emery to produce a convex surface on a level grinding-plate, the writer has given each of his copper disks a *convex curve*, the steepness of which is determined by the degree of fineness of the emery used in each particular case. The disk, for instance, which he uses for "finishing" viz., for the final application of the finest grade of washed flour-emery, has a convexity so slight that if a steel ruler be held against its surface, the deviation from the true level will be found to amount to less than 1 mm. at a distance of $3\frac{3}{4}$ inches from the centre. Yet this infinitesimal convexity completely counteracts the emery's peculiar effect and produces an absolutely level section.

The rock-slices, being completed on one side, are now cemented to rectangular pieces of plate glass, averaging one square inch in surface and about an eighth of an inch in thickness. It is of great importance that the glass should be free from flaws, bubbles or such other defects as render the surface more or less imperfect; thus ordinary window-glass should under no circumstances be employed for this purpose.

During the first year or so of his experience as a preparer of sections, the writer used hardened Canada balsam as a cement, but he found its drawbacks so great and numerous that he was soon obliged to look for something better. The cement which he now uses is a mixture of shellac and Venice turpentine, and is prepared in the following manner. Half a pound or less of ordinary shellac is melted in a flat-bottomed open vessel over a Bunsen burner. Then an equal quantity of Venice turpentine is carefully added under constant stirring. The mass should be allowed to boil for about ten minutes, during which the stirring is continued. Then small quantities are poured in separate heaps on an iron plate or other cold surface and rolled into sticks about seven inches long and half an inch thick. Two or three of these sticks may be all that the average petrographer is likely to require in the course of a year; the writer uses them at the rate of about fifteen per month. This cement is excellent and cannot be too strongly recommended; it is unsurpassed in adhesiveness and its general qualities are so admirable that he who has once used it will never again resort to Canada balsam.

CEMENTING.

In order to affix the specimen to the piece of glass, heat the latter carefully over a spirit-lamp or Bunsen burner, place it on a flat piece of wood and apply the end of the shellac stick till a sufficient quantity of the cement is dissolved. Then heat the slice in the same manner, and before placing it on the glass, rub the shellac stick well over it. It should be so hot that the shellac is melted the moment it is brought in contact with it, yet without causing the cement to boil or smoke. Then the slice, with its finished and shellac-coated side, is placed on the glass and pressed down with considerable force, so as to squeeze out all the superfluous cement.

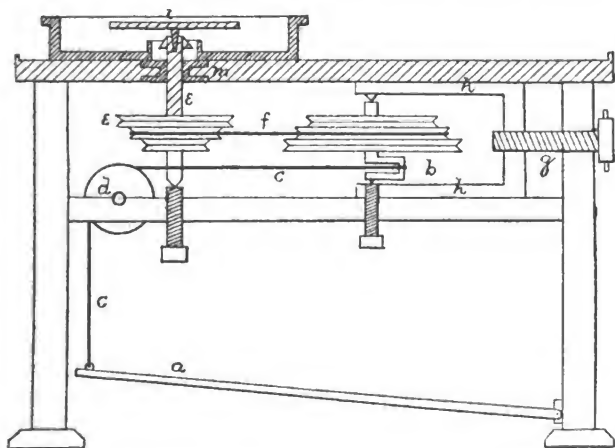
If air-bubbles should appear in the layer of shellac between the cemented surface and the glass-plate, we may conclude that either the latter or the rock-slice (possibly both) have been over-heated. It is difficult to expel these atmospheric demons by mere mechanical pressure, although, if only a few small bubbles are present, they may sometimes be got rid of in this way, especially if the section is rapidly moved to and fro, viz., rubbed against the glass-plate during the operation. As a rule, however, it will be necessary to remove the section from the plate and apply some fresh cement, taking care not to heat the glass-plate more than necessary, and repeat the process. Air-bubbles should not, under any circumstances, be allowed to remain under the cemented surface, as during the final stages of grinding, those parts of the section which are situated over air-bubbles, viz., unsupported by a cement-layer, almost invariably break and disappear, so that the section shows as many perforations as there were air-bubbles or vacant spaces in the cementing medium.

GRINDING TOOLS.

The first process of rough grinding is best effected on a copper-disk, seven or eight inches in diameter, and at least half an inch in thickness. Lead-laps are also extensively used as grinding-plates, and in one respect they are superior to copper-disks, viz., if the element of time is of special importance. The softer the grinding-plate, the quicker the grinding process, which seeming paradox is easily explained if we bear in mind that it is not the surface of the disk, but solely the emery which effects the grinding. The disk merely furnishes a support for the grinding medium, and the softer

the metal of which it is composed the better it will hold the emery and the more energetic will be the action of the latter.

Lead-laps, however, are so quickly worn out and require such constant re-adjustment, that the trifling gain in time is more than counterbalanced by corresponding drawbacks. Cast-iron plates, on the other hand, which are recommended by some workers, give as little satisfaction, on account of the slowness of the grinding-process, although their surfaces are but slightly affected by prolonged use. Lead and iron, in the shape of grinding-plates, represents two extremes which it is best to avoid, and the writer has found in copper a happy medium, inasmuch as it combines the advantages of both, with but a modicum of their drawbacks. A copper disk, if judiciously handled, will keep its level surface for a year, even when constantly used for rough grinding; whereas a lead-lap, during the same period, would require a dozen renewals.



Grinding and Slicing Machine.
Hensoldt Model.

This machine is so constructed that it can be taken to pieces in a few minutes and securely packed in a box, measuring $3\frac{1}{2} \times 2 \times 2$ feet. The treadle (*a*) is connected with the crank of the fly-wheel

(*b*) by means of a catgut cord (*c*), which is supported by the treadle-wheel (*d*). The motion of the fly-wheel is communicated to the driving-pulley (*e*) through a belt (*f*) which can be conveniently adjusted (tightened) by a large wooden screw (*g*) attached to the sliding-gear (*h*) which carries the fly-wheel. The spindle of the driving-pulley (*e*) has a conical perforation which admits the pin of the copper-disk (*i*). The latter may be replaced at any moment by another grinding-plate, emery-wheel, or diamond-saw. A funnel-shaped brass-ring prevents grains of emery, etc., from intruding between the spindle and the steel collar (*m*).

A machine constructed after the above pattern may be seen at the School of Mines (Geological Department). It has been in use for several years, has given the utmost satisfaction, and is still as good as new.

One of the fundamental mistakes of many preparers of sections consists in their using the same metal-plate for both coarse and fine grinding. Either for reasons of economy or from sheer thoughtlessness, they provide themselves with but a single disk on which they use every grade of emery. After a copper-plate or lead-lap has been used even a few times for rough grinding with coarse emery, a slight wearing out, or hollowing, in the region between its centre and periphery, is unavoidable, which, even in the case of cast-iron plates, will prevent the operator from obtaining a true level section-surface during the final grinding process.

(To be continued.)

EXTRACTS FROM PRESIDENTIAL ADDRESS TO THE BRITISH SOCIETY OF MINING STUDENTS.*

By HERBERT W. HUGHES, F.G.S.

. . . . SAFETY LAMPS.—Under the head of safety lamps, we have been favored with descriptions of the Hepplewhite-Gray, and one for firing shots patented by Messrs. Heath and Frost. As a detector of gas the former is undoubtedly superior to all others on

* Delivered at the Mining School, Wigan, July 26th, 1889.

the market, and it does so without causing an explosion in the lamp, and in addition the light given is of a superior character. Its only disadvantage seems to be the ease with which it may be extinguished when suddenly brought into a rapid current of air. As a fireman's lamp, I think it is in front of all others; with some lamps, when passing hurriedly from one place to another, it is possible to miss a small quantity of gas, but with the Hepplewhite-Gray this could not be done. Speaking generally of safety lamps, I may say that something more is needed in them than the fact that they are safe in a certain velocity of air-current. Experiments on different types are carried out at the surface, and the trials are conducted in a current of cool, fresh air mixed with certain percentages of gas. Down the mine the conditions are essentially different. The current of air is mixed with other gases than carburetted hydrogen, the temperature is considerably higher, and, in addition, varying quantities of coal-dust are present. Under such circumstances the practical working of some of the modern safety lamps is not quite the success one would have expected from the results of trials which have been conducted on them. Speaking from experience about one of the lamps recommended by the Royal Commission on Accidents in Mines, its use is attended with numerous disadvantages. In a short space of time, in a sluggish air-current, it gets so hot that one can scarcely carry it, and the light decreases rapidly owing to the clogging of the gauze by coal dust, etc. For the working miner the Marsaut lamp appears to possess several advantages; its construction is simple and strong, it gives a good light, burns steadily in a whirlwind, gives a reliable indication of gas, and is safe in explosive currents of high velocity.

EFFECTS OF WORKINGS ON THE SURFACE.—It is only by the multiplication of facts with details of the constitution of the strata and particulars of the inclination of the beds that any one can form opinions as to the probable effect and direction of subsidences. The whole subject seems enveloped in a veil of mystery, and most contradictory results are obtained. Callon, in his lectures on mining,* after an able review of the whole matter, comes to the conclusion that subsidences take place at right angles to the planes of stratification, and that this subsidence continues without sensible diminution in amount quite up to the surface, whatever may be the

* Vol. ii, p. 306.

depth of the beds, and upon this argument the case cited by Mr. R. W. Dron was decided. Now, in South Staffordshire, as the members are aware, we have a very thick seam of coal. In certain districts the mines belong to the lord of the manor, and the surface to other individuals, and the former has power to work the mines without liabilities as to payment for injuries to the surface. As a result, the mines are worked without any consideration as to the effect they will produce on the surface, and although the district affords in places a striking example of the damage caused by removing thirty feet of coal in one operation, careful experiments on the amount of subsidence and draw have not been carried out. One point has, however, been satisfactorily demonstrated, and that is, that although in the great majority of cases subsidence takes place at right angles to the plane of stratification, in others it proceeds in a vertical direction. Where the beds are of a hard, tenacious character, such as sandstones, etc., the fracture is at right angles, but on the other hand, if they are soft and friable, it takes place vertically. The method of working also affects the result. When a seam is worked and stowing employed, subsidences of greater amount may be obtained, than sometimes happen if a thicker seam be extracted and the roof allowed to fall in. In the former case, a gradual compression of the gob takes place with a corresponding sinking of the overlying strata; in the latter case, the rocks are broken and fall into the cavity caused by the workings, and as their bulk in the broken state is greater than it originally was, the opening gradually becomes less, until at the surface subsidence is scarcely noticeable. In a letter from the celebrated viewer, John Buddle, to Sir Charles Lyell, the former states that he invariably found that subsidence is always greater under a sandstone than under a metal-stone cover, and that whenever a lower seam is worked after an upper one has been removed, a second set or lowering takes place. Whether this action went on indefinitely he was not prepared to say, but in the working of three successive seams the phenomena had been noticed. The amount of each subsidence was not measured, but the whole amount of the settlement of the surface was five feet six inches, and the aggregate thickness of the three seams worked out was fourteen feet eleven inches. The method of working employed was bord (breast) and pillar, and the depth from the surface varied from 73 fathoms in the first seam to 107 fathoms in the third. The amount of subsidence is small, but

this is accounted for by the fact that the points of observation were situated at one end of the excavated tract and not near its centre.

ELECTRICITY IN MINES—Many collieries are now equipped with the electric light, and the number is increasing daily. The cost of conductors is one of the chief items in putting down installations, and this has been remedied at Cannock Chase Collieries by using old pit ropes for this purpose instead of the copper cables generally employed. Excellent results have been obtained. The insulation is effected by laying the ropes in ordinary gutter-bricks which have a semi-circular recess, and placing the whole in a trench cut to receive it. The space between the brickwork and rope is filled in with a mixture of coal dust, lime and tar, poured in hot and allowed to cool. Coal-dust is an excellent non-conductor, as a layer $\frac{1}{16}$ inch thick interposed between two copper plates opposes a resistance of quite 1,000,000 ohms. This method of laying cables and the materials (ropes) employed, are strongly recommended for colliery purposes, but at the same time their use would be inadmissible for larger installations. I am rather surprised that more power applications have not been put down in this country. Many persons look on electricity with a certain amount of suspicion, and consider it as being capable of further improvement. It would be foolish on any one's part to say that no improvement is possible, but at the same time it is improbable. When we consider that dynamos are capable of transforming 90 per cent. of the power transmitted to them into electricity it will be readily admitted that the margin is sufficiently close. The same remarks apply to motors, which will transform over 90 per cent. of the electricity transmitted to them into work. The solution of the problem of obtaining more work from the coal will probably come about by some other means. Every one is familiar with the easy transformation of electricity into heat, but up to the present, inventors have failed to transform heat into electricity. Looking at the immense strides which have taken place in this science during the past few years, it is not at all improbable that we may soon have some means of generating electricity from heat directly, without going through the laborious and wasteful operation of burning coal under boilers to form steam, and then converting the product into work by means of an engine. Another point deterring the mining student from taking up electricity is the difficulty he has in understanding the meaning of the technical terms used. We are familiar with "feet

of head," "pounds," "gallons," etc., but inasmuch as electricity has neither weight nor bulk, and travels equally well up hill or down hill, it is perfectly obvious that some other terms than these must be employed when speaking of its measurement and pressure. I have endeavored to explain these terms and their analogues in ordinary measurement in the paper contributed to the last number of the *Journal*. The paper by Mr. Brain satisfactorily disposes of the remark sometimes made that electricity is in a state of infancy. If any one will carefully read and digest that contribution, he will soon come to the conclusion that such is not the case, for it must be remembered that every example given is a fact and not a supposition. Since that paper was written, what is at the present time the largest electrical power installation in the world has been satisfactorily put to work at the famous Comstock Mines, in Nevada, and of which the following is a brief description: Six Pelton water wheels, 40-inch diameter, drive a similar number of dynamos of 135 horse-power. The dynamos and waterwheels are situated in a chamber measuring 50 feet long, 25 feet wide and 12 feet high, specially excavated in the mine at the depth of 1630 feet, and the water to drive the wheels is conveyed to them from the surface under this enormous head. The waste-water runs away down the Sutro adit. The current is conveyed to the surface by a copper wire three-eighths of an inch diameter, and there drives six electric motors of 90-horse power each, which furnish power to hoisting-engines, ore-dressing machinery, etc. Seventy per cent. of the power applied to the shafts of the underground generators is delivered for work at the main shaft in the mill, and, in addition, between 60 and 70 per cent. of the amount of water formerly used is now saved.

COAL SUPPLIES OF GREAT BRITAIN.—The consternation caused by Mr. John Stuart Mill's statement that our coal supplies were measurable, was increased by the memoir of Mr. S. Jevons on the same subject, and, as a result, the Royal Coal Commission was appointed to inquire into the amount of coal existing in the United Kingdom, and to determine, if possible, how long our coal supplies would last. In 1871 this commission issued its report, where, after going fully into calculations, and making exhaustive inquiries, it was stated three hundred and fifty years would see our mines worked out. Such an interval of time is a long period in the lives of men, and once the nation became accustomed to the idea that at

some distant time our coal-fields would be worked out, their former indifference to the matter was soon manifested. Mr. Williams goes carefully over the ground covered by the Coal Commission, and accepts their calculations as to the amounts of coal in the known coal-fields, but at the same time most clearly demonstrates that the rates of increase on which the Commissioners based their calculations has been much exceeded, and that the estimates they made as to the life of the coal-fields cannot now be accepted as correct. After describing in detail the actual increase in consumption, and pointing out how they differ from the calculated increases of the Commissioners, Mr. Williams comes to the conclusion that the present coal-fields of the United Kingdom will be exhausted in 102 years. The chief point of difference between the actual figures of to-day and the estimates of the Commissioners is in the amount of exports. The Commissioners considered that an average of 12 million tons per annum would meet all future demands, but this amount was exceeded in the same year that the report was issued, as the exports then arrived at the quantity of $12\frac{1}{2}$ million tons. Year by year an increase took place, until in 1888 the exports amounted to nearly 27 million tons, having more than doubled in the past seventeen years. Although acknowledging the care with which Mr. Williams's figures have been compiled, it is impossible to agree with all the hypotheses he draws from them. It must be remembered that he deals exclusively with the quantities of coal existing in the known coal-fields of the kingdom, and does not take into consideration the enormous bulk of minerals which, in all probability, exists under secondary formations. My own district forcibly illustrates the true position of affairs. In certain areas the famous thick coal is practically exhausted, and many years ago eminent engineers drew attention to the fact that at no distant date this seam would be worked out. What are the real facts of the case? Owing to proofs over faults and under secondary formations, and neglecting other areas where every probability points to the existence of coal, it may be broadly stated that at the present time more thick coal exists in South Staffordshire than there was *considered* to be in it twenty years ago. Numerous other coal-fields could be mentioned where similar extensions of their boundaries have taken place. Then, again, can we reasonably expect that our output will go on increasing at the present rate? Surely some limit must be placed upon it. Taking

exports, for instance, if they increase in the way they are doing, in thirty-four years from now they will have reached the enormous figure of 165 million tons, *which is more than the whole total output of the Kingdom in 1887!* All probabilities point strongly to the fact that the present rate of increase cannot be maintained. The chief one, in my opinion, is the question whether our country will be able to support the large increase in population required for the estimated output of say fifty years hence. It may be argued that as improvements are introduced, every man employed in mining coal will turn out a larger quantity of mineral than he does at present. If we examine the records for the past few years they will not bear out such a contention. The figures since 1881 are as follows:

Year.	Total number of persons employed.	Statute tons of minerals wrought.	Production per man per annum.
1881,	495,477	168,959,931	321 tons.
1882,	503,987	171,334,032	339 "
1883,	514,933	178,763,390	326 "
1884,	520,376	174,872,759	336 "
1885,	520,632	173,223,960	332 "
1886,	519,970	170,006,959	327 "
1887,	526,277	173,049,795	329 "

So that instead of an increase, we practically remain in the same position. Unless some radical change occurs, the figures seem to indicate that to double the output the number of persons employed will have to be doubled also. On the other hand, it may be argued, that as mining is carried on at greater depths and under less favorable circumstances than it is at present, every man employed will actually produce less coal per annum. Undoubtedly, the tendency of our day is for the population to migrate to industrial centres and leave the agricultural ones, but even taking this into account, it must be remembered that in addition to the larger number of miners who will be necessary to produce the future output, more artisans will also be required to use the increasing supply in the various processes of manufacture which coal aids. The probabilities raised by such a suggested increase in population cannot be satisfactorily dealt with in such a brief review as the present address must necessarily be. Even supposing the increase in output possible, and the exhaustion of our coal supply to take place in the hundred years given to it, would it be advisable by any measure of restriction in output to delay the inevitable end? Our foreign coal trade is an

integral and essential part of our system and the measure of our commercial prosperity. To restrict output would increase prices, and cheap coal is a necessity, if we are to retain our place among nations. To enjoy the manifold advantages we do at the present time, coal must be raised as cheaply and disposed of as quickly as possible, and it would never do to sacrifice our present position in view of some sentimental and remote contingencies as to what may happen in the future. The inevitable day must come when we shall fall behind our competitors in the coal race, but even then, sentimental regrets as to the non-existence of our works and collieries would be out of place.

THE THERMO-ELECTRIC PYROMETER OF M. LE CHATELIER.

BY JOSEPH STRUTHERS.

THE principle upon which this pyrometer is constructed is, as the name indicates, the measurement of a current of electricity produced by heating a couple composed of two wires, one platinum and the other platinum with 10 per cent. rhodium—the current produced being measured by a galvanometer.

There are two forms of this pyrometer differing in details of construction; one for laboratory use and the other for the measurement of industrial temperatures. The pyrometer consists of the couple which produces the current, the galvanometer which measures it and the conductor connecting the two.

The couple is composed of the platinum and platinum-rhodium wires, joined at one end and introduced in the circuit, and can be heated its entire length without producing the opposite electric current, caused by the heating of the solder or weld at the juncture with the conductor; an essential quality for the industrial application of these couples.

These wires are of perfect homogeneity and do not have their thermo-electric properties altered by hammering; they may be joined together in various ways; by soldering with palladium or gold, by simple twisting or by forging, the indication of the appa-

ratus being the same in all cases—these qualities permitting easy repairs in case of rupture.

The composition of the gas which surrounds the couple has no influence on the indications, and to this advantage is to be added the important one which the couple possesses by virtue of its form, the long and slender shape rendering possible the taking of temperature at any point in a furnace. When temperatures above 1400° C. are to be studied, the wires must have an isolating support and must be of good length, so that all parts of a furnace can be reached.

For a Siemens furnace, 3.5 metres is the general length. The wires are supported in an iron tube, 13 mm. interior diameter and held in place by a cylinder of refractory clay having two holes bored through in which the wires are placed; a wooden handle is sometimes connected to the tube by two rings as a bayonet to a gun, thus giving greater length. The shortness of time (five seconds) allows the temperature to be taken without deteriorating the tube; the only precaution necessary is to allow the wires to extend a few centimetres beyond the outer end of the iron tube. Other arrangements may be used, as when the continuous temperature of a furnace is required in which case the wires may be introduced through a permanent opening in the arch thus supporting themselves.

The galvanometer used is the reflecting galvanometer of Déprez and d'Arsonval, a detailed description of which can be found in any standard work on electricity. MM. le Chatelier and Carpentier have made several valuable improvements which render its manipulation more practical.

This galvanometer consists of a strong permanent horseshoe magnet between the poles of which, placed vertically and supported by a standard, a piece of soft iron serves to increase the intensity of the magnetic field; around this piece of iron (and so suspended that it will not touch either the iron or magnet) is a rectangular frame of fine wire supported and held in vertical position by two very fine wires of German silver, these serving also to conduct the current to the frame; these wires form a torsion-balance in which the strength of torsion produced by the angular movement of the frame serves to counterbalance and thus measure the reciprocal action of the frame.

To intensify the deviation of the frame, a small mirror is perma-

nently attached to the upper part on the axis of suspension which reflects a ray of light and an image on a divided scale.

The wires of the frame are of copper or German silver, the former having a less resistance and giving, other things being equal, a stronger current and greater deviation, but its resistance varies with the temperature ten times as much as German silver, thus necessitating corrections for slight changes of temperature, which could be avoided if German silver were used.

Copper is usually employed for accurate measurements at high temperatures; German silver, when the temperature is below 600° C.

The delicacy of this apparatus is such that it will indicate distinctly a current of $\frac{1}{1000000}$ ampere; it is a *galvanomètre apériodique* or dead-beat, as the equilibrium of the frame establishes itself very quickly and the image acquires a fixed position on the scale; finally, it gives deviations proportional to the strength of the current within an approximation of one per cent.

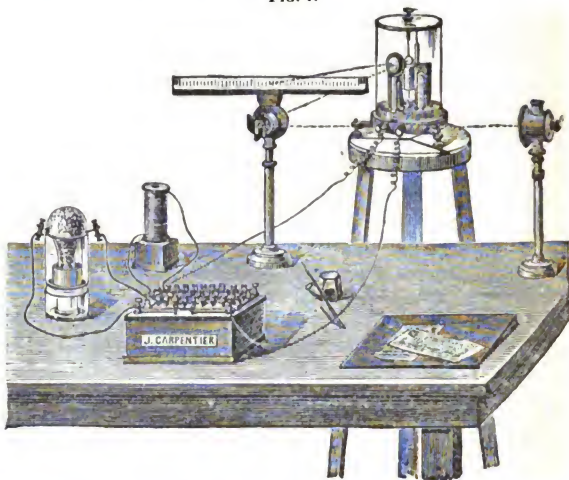
The conductor is generally very long, to allow the location of the galvanometer at any place in the building, and on account of the delicacy of the galvanometer, it is best to have it permanently fixed; a length of wire about 50 metres being sufficient to take the temperature of several furnaces; this wire is generally rolled on a bobbin and is always a part of the circuit, thus avoiding the variation of the resistance of the conductor. The disposition of the wires of the conductor is of no importance; they may be strung on permanent supports, along the wall of building, etc.

The disposition of the apparatus for laboratory use is illustrated in Fig. 1, showing the galvanometer, the lamp for projecting the ray of light on the mirrors, the scale to measure the deviations and the conduction wires on the bobbin connecting the galvanometer to the wires of couple which, in this case, are introduced directly into the substance in the jar. The box of resistances here shown being used to obtain the initial resistances of the conductor and galvanometer and, as hereafter mentioned, to equalize the resistance of the galvanometer caused by variation of its temperature instead of making the calculation.

The apparatus as used for measurements of industrial temperatures differs in construction; it is contained in two wooden boxes which, for ease in transportation, can be fixed to a middle piece of

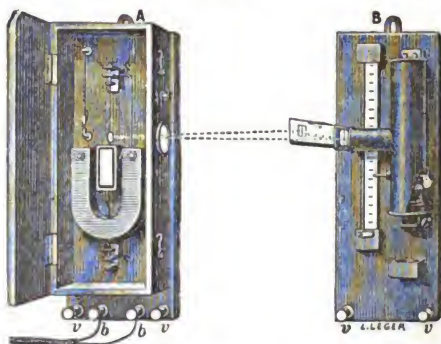
wood having a handle at one end; these boxes when removed

FIG. 1.



can be attached to a wall by means of loops A and B Fig. (2), and

FIG. 2.

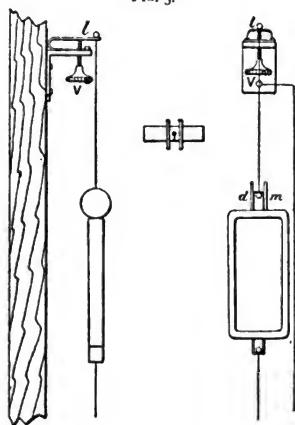


made vertical by turning the screws v, v, at the bottom, guided by a small plumb-line attached to the box on the inside.

The box A contains the galvanometer differing from the one described in the support and construction of the wire frame; these supports are fastened to the back of the box and connected by means of platinum wire to the thumb screws, *b, b*, at the bottom, by means of which the connection is made to the conductor.

In the manner of suspension, the frame differs from that of Déprez and d'Arsonval. The threads of German silver are terminated by small balls of platinum; one of the balls is held in a notch arranged on the support (Fig. 3); the other in a similar

FIG. 3.



notch arranged on the top of the frame. The same method is applied to the attachment of the lower thread. By reference to the figure it is seen that the mirror (*m*) is not placed on the axis of suspension. This is counterbalanced by means of a disk (*d*) of metal of the same weight, thus restoring the centre of gravity of the frame to the axis of suspension.

The supports are formed of a flexible copper plate, *l*, bent round to form a spring, which can be raised or lowered by means of a screw, *v*.

The use of the thread with the two balls renders the pyrometer less liable to injury by transportation, since the frame and suspend-

ing wires can be withdrawn, the other parts are very strong and substantial. By having duplicate wires, any further accident can be repaired.

During transportation it is sometimes easier to wedge the frame in place and release the suspending wires from tension. When the wires are replaced, care must be taken to place the upper and lower ones in their respective positions, as experience has shown that changing them modifies the elasticity of tension, and falsifies the indications.

An aperture with a glass cover is made at the side to admit the passage of both incident and reflected rays. This box should always be closed.

The two parts of the galvanometer can be placed on a frame of wood, where the position of the two boxes are marked, so that the distance between the scale and mirror is one metre. If necessary to remove the apparatus it suffices to hang the frame on nails and the placing in position is immediate.

Thus it is seen that in order to easily adjust this form of the pyrometer all that is needed is a vertical plane surface two metres square; this being a decided advantage over the original galvanometer which requires a horizontal table.

The box B, from which the cover is removed during the observations, contains the lamp giving a steady flame and a cylinder of sheet-iron forming a chimney. At one side of this chimney a lens is placed to obtain parallel rays, and direct them to the mirror. A screen having an opening and image is in front of this lens, the image of the opening being reflected on the scale helps to obtain an exact reading. The scale is a transparent one, moving in a groove, and placed a little oblique to the plane of the apparatus, being perpendicular to the bisectrix of the angle of greatest deviation in order to reduce to the least degree the error due to the substitution of the tangent for the arc in measuring the angle of deviation. This error, however, would be of no importance, since the angles considered are less than five degrees. In order to adjust the apparatus, the frame and the suspending wires must be made vertical; this is easily accomplished by means of the adjusting screws and plumb-line.

The luminous rays are made to fall on the mirror by raising and lowering the box containing the lamp until the image falls on the scale. It often occurs in the first use of the apparatus that the

image does not appear, owing to the lamp being out of place, or the reflected ray passing to the side of the scale. This can be overcome by placing it in a dark room for adjustment.

It is also advisable to close the circuit by attaching the wire of the conductor to the binding screws of the galvanometer, thus placing the galvanometer in closed circuit. Unless this precaution is taken the oscillations of the frame are stopped very slowly. In a closed circuit the equilibrium of the frame is restored immediately and the image acquires a fixed position. The steadiness of the image is a certain guarantee that there is no break in the wire.

The image being fixed on the scale, it is placed at zero. This is accomplished in several ways; for a great angle of deviation it is necessary to turn one of the suspending wires by imparting a rotary movement to the little ball which terminates it, using pincers or the hand; for a small deviation slightly turn the case of the galvanometer by means of one of the adjusting screws; if it is only a few millimetres from the line, move the adjustable scale in the groove which supports it. The apparatus is then ready for use.

The manipulation of this apparatus requires care and some apprenticeship, but is within the reach of any one capable of making a fine reading.

The graduation of the apparatus is made as follows: The pyrometer gives by the reading on a graduated scale in mm., the measurement of the intensity of a current produced by heating the thermo-electric couple. To deduce thermometric degrees from these readings it suffices to know the law of variation of the electromotive force with the temperature $f(E, t) = 0$, and the temperature corresponding to any two points on the scale. This law, studied by M. le Chatelier for this couple, is explained only by very complex formulæ, two equations of the parabola of three terms, and even then with an approximation of 10° only, this approximation being greater than that which the pyrometer itself gives.

The application of the formula is therefore not practical in translating the reading, but the study of the couple conducted by M. le Chatelier has a very interesting result, giving the translation very easily, between 300° and 1200° C.

M. le Chatelier quotes, in his able article on the "Measurement of High Temperatures,"* as follows: "If the relative curve of a

* Le Chatelier, "Mesures des Températures Élevées," *Journal de Physique*, 2d série, t. vi.

platinum and platinum-rhodium couple be studied, it will be observed that between 500° and 1000° it presents a point of inflection whose tangent merges into the curve to a great extent, so that between 300° and 1200° (the interval of temperature where the measures are most interesting) the curve can be represented by a straight line, of which the equation would be

$$E = -0.15 + 0.115 t, \quad . \quad . \quad . \quad (1)$$

There is thus proportion between temperature and number of division on the scale. Practically, the easiest method of translating the readings is by the use of a graphic chart, made by using points produced by heating the couple to known temperatures and from these points constructing the extended scale.

The following is the description of the graduation given by M. Damour :*

The temperatures easiest of comparison between the pyrometers and the normal thermometer are the points of the change of state bodies, the greater number of which have been the object of researches by the most able chemists. These are the fixed points borrowed from the determinations of M. Violle, which M. le Chatelier used as starting points.

Temperatures.	Fusion.	Boiling.
100	.....	Water.
325	Lead.	.....
358	.....	Mercury.
415	Zinc.	.....
448	.....	Sulphur.
665	.....	Selenium.
945	Silver.	.....
1045	Gold.	.....
1054	Copper.	.....
1500	Palladium.	.....
1775	Platinum.	.....

These different points are not all of easy use. The point of fusion of zinc appears to present an anomaly similar to that of sulphur. In heating that metal beyond its point of fusion and letting it cool, an interval of fifteen degrees is found between the point of fusion and of solidification, but if once solidified and reheated immediately the anomaly is not reproduced.

* *Bulletin de la Société des Anciens Élèves de l'Ecole des Mines, Mars et Avril, 1889.*

The fusion point of silver appears also to be somewhat variable. This anomaly could be the result of absorption of oxide of silver which the molten metal holds in solution and which is the cause of sprouting. Lastly, the three metals, Zn, Ag and Cu, have the great disadvantage of emitting at their points of fusion vapors which affect the platinum of the couple.

The points most frequently used for graduating apparatus are : boiling-water, the fusion of lead, boiling of sulphur, the fusion of aluminum and gold. The boiling of water presents no difficulty. The same is the case with boiling of sulphur, which can be done in a porcelain crucible of some depth, perhaps in a test-tube. In the latter case one must guard against the ejecting of molten sulphur during boiling.

Sulphur has no destructive action on the platinum or its alloy with rhodium. After the experiment any adhering particles can be rubbed off. In the preceding operation the image preserves a position absolutely invariable, and as the ebullition can be prolonged as long as desired, the reading can be made with great precision. When a metal, gold for example, is carried to its fusion-point, the process is a little more delicate. The end of the couple is surrounded with a foil ; or better, the couple is wound with gold wire and plunged into a crucible filled with refractory material, such as precipitated silica or magnesium carbonate. In order that the heating of the end should be very gradual, the crucible is placed on a hearth and regularly heated. M. le Chatelier used a furnace and M. Damour used Deville's turpentine lamp, giving a uniform heat.

To measure the elevated temperature the image is displaced on the scale without a stop up to the point corresponding to fusion of the gold. At that moment the quantity of heat necessary to change its state causes a retardation in the progress of the image and a short period of rest, followed by a brisk jump of 1 or 2 divisions on the scale, indicates the degree on scale to note.

When the first attempt is made with a new couple and galvanometer the reading is generally a little difficult, owing to the production of some temperatures which cause rests on the scale and tend to deceive the operator. Usually after one or two trials one knows to within a few mm. of the right stopping-point, and error is no longer possible.

Lead and gold do not attack the couple. The fusion-point of aluminum which has been determined by M. le Chatelier is equally easy to use, and possesses the advantage that it gives a temperature intermediate between the boiling-point of sulphur and the melting-point of gold.

A temperature higher than the fusion-point of the metals of the couple is indicated by the breaking of the circuit. Below is given a complete table of the results of the experiments of M. le Chatelier which served to trace the curve. Other known temperatures of fusion and volatilization could be used as fixed points on the scale.

	Fixed Points.	Deviations Observed.	Calculated Temperatures.
H ₂ O,	100	5.5	.....
NH ₄ Cl, . . . . .	.....	25.6	340
Hg,	358	27.7	.....
S,	448	36.3	.....
Al, . . . . .	.....	57.3	625
Se,	665	61.8	.....
K ₂ SO ₄, . . . . .	.....	102.5	1015
Au,	1045	105.6	.....
Pd,	1500	161.	.....
Pt,	1775	182.	.....

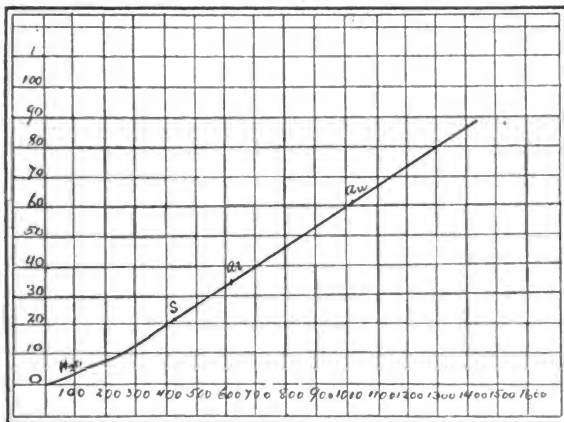
A. Rigaut* gives the following table of verification of results obtained:

	Temperatures Admitted.	Degrees Observed.
Boiling of water,	100	100
“ NH ₄ Cl,	340	344
“ S,	448	443
“ Se,	665	669
Fusion of Au,	1045	1042
“ Pd,	1500	1514

The following is a chart showing the curve of temperature traced in the laboratory of the Ecole d'Mines with a galvanometer having an internal resistance of 250 ohms, which gave on the scale a displacement of 100 mm. for $\frac{1}{100}$ volt. The temperature of the apparatus and of the point of juncture of the wires of the couple to the conductor being 17° C.

* *La Lumière Electrique, Samedi, 17 Mai, 1890.*

FIG. 4.



By inspection of this chart it can be seen that the tracing of the temperature curve on paper is rendered very easy if the paper is squared to lines 1 millimeter apart. The abscissas are taken from the temperatures to the scale of 1 to 5, that is, 1 mm. to 5° C. The ordinates are taken from the deviations of the galvanometer to the scale of 2 to 1.

This example may be used as a guide for the first graduation. However, it is important to remark that the results on the scale of one pyrometer cannot be expected to agree with results on the scale of others, and also, that results obtained by the same pyrometer under different conditions will vary. As a precautionary measure it is advisable to verify the chart from time to time whenever the pyrometer is to be used for very exact temperatures, and in this way avoid any cause of error.

The causes of error and the corrections of the readings are very ably discussed by M. Damour. In his article before mentioned he presents them in the following manner:

CAUSES OF ERROR IN THE INDICATIONS OF THE PYROMETER AND THE CORRECTION OF THE READINGS.

From the preceding description it is always easy to refer the readings made by the pyrometer to normal thermometric degrees.

The verification of the scale made in the course of the testing allows suppression of the causes of error and arrival at an approximation of 5 to 10° C., such being the conditions of the apparatus. But in industrial measurements, which have to be made rapidly, there is no time for verification.

The errors are due to two sources, the galvanometer and the exterior circuit.

The Galvanometer.—Some authorities question the constancy of the dead-beat galvanometer, claiming that the permanent magnets are affected by time. It is well, therefore, to verify, from time to time. All that is necessary is to pass a current of known intensity and to measure the corresponding deviation. A pile having a strong current of constant force can be used, but this is difficult to obtain, and when used, necessitates the introduction of resistance-coils. The easiest way is to employ the couple of M. Chatelier, which is considered unalterable. It can be heated to a fixed temperature, such as the fusion of sulphur, and the deviation produced by the known electric force can be measured. This brings us back to the remaking of the graduation (chart), which is always advisable to insure absolute results. This cause of error, therefore, merits no further discussion. The variation of temperature also affects the galvanometer. It is of great importance, but the correction is easy, knowing the ratio of the deviation to the intensity. Take, for example, the use of the copper frame in the instrument tested by M. Damour; the resistance was 208 ohms, the increase of the resistance of copper for each degree centigrade between 0° and 100° is 0.00388 per degree.* Suppose the graduation was made at 15°. In order to determine the correction which should be made if the galvanometer was at 16°, let R = resistance of the galvanometer; then at

* The coefficient of correction is not absolute; it varies with the difference between the two temperatures. The exact formula would be:

$$\frac{n - n'}{n'} = \frac{a(t' - t)}{1 + at}$$

in which

n = number of degrees observed on the scale.

n' = " " " which would be observed if
the galvanometer was at the temperature of its
graduation.

t = the observed temperature of the galvanometer.

t' = the temperature of galvanometer when graduated.

$$15^{\circ} \quad R = 208 (1 + 0.00388 \times 15) = 220.10$$

$$16^{\circ} \quad R' = 208 (1 + 0.00388 \times 16) = 220.90$$

$$R' - R = \underline{\quad 0.80 \quad}$$

$$\frac{R' - R}{R} = \frac{0.8}{220} = 0.36 \text{ per cent.}$$

The resistance being increased 0.36 per cent., the deviation of frame is less. It is therefore necessary to adjust the reading made on the scale to conform with the increased resistance. The extent of error can be estimated in thermometric degrees as follows:

The greatest deviation is 200 mm. corresponding to nearly 1100° which allows 5.5° to each mm., the correction being

$$\frac{0.36}{100} \times 200 = 0.72$$

$$5.5 \times 0.72 = 3.9^{\circ}.$$

In practice, these errors can be adjusted even when the increased resistance is as much as 2 per cent. which equals 25° to 30° temperature.

(Another method is used for this correction and that is to introduce in the circuit coils of known resistance, and by their introduction or removal from the circuit, counterbalance the difference of resistance of galvanometer caused by a lower or higher temperature.)

It is consequently necessary with the copper wire frame, to take the temperature of the location of the galvanometer by a thermometer; when the difference between the temperature of the galvanometer and temperature taken when the chart was made exceeds 2° , correction must be made.

It is not the same with the frame of German silver, since the increase of resistance is $\frac{1}{3}$ that of copper, equalling 0.044. When a frame of German silver wire is used, the following would be the formula to calculate the correction.

A frame having resistance of 242 ohms, gave at a temperature of 1500° , a deviation of 100 mm.:

$$R = 242 (1 + 0.00044 \times 15) = 243.6$$

$$R' = 242 (1 + 0.00044 \times 16) = 243.7$$

$$R' - R = \underline{\quad 0.1 \quad}$$

$$\frac{R' - R}{R} = 0.041 \text{ per cent.}$$

which represents a maximum error of 0.6° at the temperature of

1500° C. For differences of 5 or 6 degrees, the error is not worth while to carry to the thousandths, and is rejected.

Thus the German silver frame has the advantage of being able to reject the correction due to slight changes in temperature of the galvanometer; but as the copper possesses a sensibility three times as great, and the correction for change in temperature can be made so easily, the advantage of the frame of German silver wire is questionable.

The calculations for these corrections are rendered very easy by employing a graphic method, in which case, all that is necessary is to trace the two curves corresponding to the extreme temperatures, and for intermediate temperatures to apply simple proportion to the portion of the ordinates between these two curves.

The Exterior Circuit.—This is composed of the conducting wires and the couple; the conducting wires are of necessity very long in industrial measurements. It might be feared that this would sensibly influence the deflection and diminish the sensibility of the galvanometer by introducing that amount of resistance outside of the galvanometer. This influence, however, is insignificant. The conductor used being of copper wire, 0.9 mm. diameter, of a resistance of 0.025 per metre; 100 m. wire, giving 2.25 ohms being $\frac{1}{100}$ the resistance of the galvanometer itself, the variations due to temperature being in the thousandths, can be passed over.

The conductor can be thus lengthened to fit the position of the galvanometer and the temperature may be taken 150 m. from the furnace.

The Couple.—The resistance of the couple when heated to very elevated temperatures has a particular importance in those measurements where it is necessary to have long wires of platinum and platinum-rhodium.

To ascertain the limit of error in a couple $3\frac{1}{2}$ metres in length, which we supposed to be heated its entire length to the same temperature as the juncture of wires in couples, say 1500°, the resistance of the couple would be about 2 ohms per metre, the double wire giving a total of 7 ohms resistance at 1500°; the increase of resistance is 0.6 per cent., giving 4.2 ohms, the error thus equalling $\frac{4.2}{242} = 1.6$ per cent.; this is large enough to apparently falsify the results, inasmuch that in making the correction, it is assumed that the temperature of the weld and the entire length of wire is equal—an hypothesis inexact and general.

There are two ways of obviating this difficulty.

If the couple is placed directly in the furnace in an isolating envelope, all that is necessary is to make the graduation of the galvanometer under the same conditions, and the fusion points of metals, such as lead, aluminium and gold, are taken as the fixed points. The observation of the points of arrest on the scale is a little more difficult than the laboratory experiments.

When the couple is in the cylinder of clay, and protected by a tube of iron, it suffices to take the reading just before the wires are heated. It does not take more than five seconds for the frame to assume a position of equilibrium, and with an interval of time so short, the elevation of the temperature of the cylinder can be neglected.

As the deviation of the galvanometer results from an electromotive force due to the difference of temperature between the juncture of the wires with the conductors, and the juncture of the wires themselves, it is therefore necessary to note the temperature of the junction of the couple wires to the conducting wires, and if it varies appreciably from the temperature made at the time of the graduation of the apparatus, to adjust the readings made on the curve of the temperatures. This is on the supposition that for the same difference between the temperatures of the junctures the electromotive force is the same, irrespective of what those temperatures may be, and this supposition is verified in practice by proving that the two curves produced, when the end was at 0° and at 25° C. respectively, are parallel. The temperature of the juncture of the couple and conducting wires can always be adjusted by pouring water on it.

Daily tests made by this pyrometer in measuring furnace temperatures under a great variety of conditions, show that the readings of the scale uncorrected are always within 25° of the correct temperature, and in the majority of industrial measurements this is sufficiently accurate.

If greater precision be required, by following out the simple graduation and making the few corrections indicated, the temperature can be approximated within 10° .

Thus the pyrometer is not only an excellent industrial one, as by its use the temperature of furnaces can be easily and absolutely controlled, but also one of great scientific importance, affording the means of opening up researches which have heretofore been impossible, owing to the inability to obtain sufficiently close approximations of temperatures.

THE OPERATIONS OF THE UNITED STATES
GEOLOGICAL SURVEY.

By H. M. WILSON.

THE United States Geological Survey is making steady progress in its several fields of labor. Though the irrigation branch of this bureau ceased to exist last August owing to the failure of Congress to appropriate for its continuation, still active and good work is being done by the topographic branch of the survey in reporting on storage reservoir sites discovered by the field parties while prosecuting their topographic labors. The bill as passed by the last session of this Congress authorizes the Director of the United States Geological Survey to report for segregation and reservation from sale or entry, any reservoir site which the topographers may discover.

During the field season just closed, about 200 such sites were discovered by the topographers working in the arid regions, of which the majority are in Montana, New Mexico, Colorado and California. Whenever an apparently good site was noticed, a rapid plane-table and level survey was made of it, usually on a scale of 1000 feet to one inch, and this survey was connected with the corners of the United States Land Survey, so that the location could be identified and the lands reported for withdrawal.

In addition to the discovery of reservoir sites, the work of tabulating and mapping the results of the surveys goes on rapidly in the office, and the reports will soon be ready to go to press. The director has just completed and sent to the Public Printer the second volume of the *Eleventh Annual Report of the Geological Survey*, which contains the report on the operations of the irrigation branch.

From this report it appears that stream gaugings were maintained by the hydrographers on all of the more important streams of the West during the years 1889-90, from which a mass of valuable information has been obtained regarding the discharge of these streams during the different seasons of the year, thus showing the water-supply available for purposes of irrigation. Some valuable experiments were conducted to ascertain the best apparatus and mode of conducting these gaugings. Experiments and observa-

tions were made to ascertain the amount of evaporation and seepage in various localities and soils; and the available rainfall statistics were utilized to obtain the percentages of run-off for different catchment basins.

The engineers made detailed surveys and reports on 33 storage reservoir projects and nearly a dozen great canal systems, besides making preliminary reports on over 250 water storage and canal projects and recommending them for more detailed examination. The work of this branch was under the charge of a corps of experienced engineers; Major C. E. Dutton, U. S. A., was the chief engineer, under whom Mr. Wm. Ham. Hall, ex-State Engineer of California, was supervising engineer of the Pacific drainage, and Mr. E. S. Nettleton, ex-State Engineer of Colorado, was supervising engineer of the Atlantic drainage basin. Among the executive engineers were, A. D. Foote in charge of the Snake River Basin in Idaho, H. M. Wilson in charge of the Missouri River Basin in Montana, S. H. Bodfish of the Arkansas River Basin, W. W. Follett of the Rio Grande Basin and a few others in charge of minor circuits.

The surveys of the 33 detailed projects included the mapping of the reservoir sites to a scale of 400 feet to one inch, with contours at intervals of four feet apart, thus enabling the contents of the reservoirs to be accurately calculated for any depth of water. Estimates of the water supply of the catchment basins of the reservoirs were made from the work of the hydrographers and topographers, and a careful study made of the areas of irrigable lands, soil and crops. The canal lines for commanding these lands were run out and cross-sectioned, and designs and estimates have been submitted showing the quantities of material required in the dams and the amount and kind of excavation in the canals, with estimates of the cost of the works and their probable financial return.

In addition to the eleventh annual report of the director, which goes over the whole ground in a general manner, five other reports are in preparation. These include a volume of the *Statistics of Irrigation in the United States*, which is being prepared for the Eleventh Census by Mr. F. H. Newell, special census agent for irrigation; a volume by Mr. H. M. Wilson which gives the detailed results of the labors of the engineering branch, besides descriptions of some of the more important works completed or under construction by private engineers in various parts of the country; a volume

on *Irrigation in India* by Mr. Wilson, embodying the results of his examination and study of the works of that country made during a recent trip to India for that purpose. And lastly, a volume giving a summary of the progress and works of irrigation in France, by Prof. C. A. Keniston, C.E.; in Italy, by Francis Fava, Jr., C.E.; and in Egypt, by H. M. Wilson, C.E. All of these reports will be gotten up in the excellent manner which characterizes the publications of this bureau, and will be liberally illustrated with maps, photo-engravings and diagrams.

Rapid progress is being made in mapping the territory of the United States by the topographers of the United States Geological Survey under the general charge of Mr. Henry Gannett, chief topographer. During the field season just closed there have been mapped in the southeastern division, under Mr. Gilbert Thompson, 13,000 square miles in Maryland, Kentucky, Tennessee, West Virginia, Virginia, Georgia and South Carolina. The work of this division is published on a scale of two miles to one inch and in fifty-foot contours. The central division, under Mr. J. H. Renshaw, has mapped 5300 square miles in Wisconsin, Illinois, Iowa, Michigan and Arkansas to scales of one mile to one inch and two miles to one inch, and in twenty and fifty-foot contours. The Texas and Kansas Division, under Mr. R. U. Goode, has completed the survey of 17,000 square miles, to a scale of two miles to one inch and in twenty-foot contours. The Northeastern Division, under Mr. H. M. Wilson, has mapped 5000 square miles in Pennsylvania, New York, Connecticut and Maine, to a scale of one mile to one inch, and in twenty-foot contours. In Louisiana and Florida, 2200 square miles were mapped to a scale of one mile to one inch, and with from five to twenty-foot contour interval, and the parties in that division have again just taken the field for the winter.

The Western Grand Division, under Professor A. H. Thompson, has mapped 21,000 square miles in California, Nevada, Idaho, Montana, Colorado and New Mexico, to a scale of two miles to one inch, and in contour intervals varying from 20 to 100 feet, according to the nature of the topography, besides locating and surveying 200 reservoir sites, as before stated.

The total area mapped to date since the organization of the survey in 1881, amounts to 500,000 square miles, of which about one-half is in the arid west.

The survey of Connecticut, the fourth State mapped by co-operation with the United States Geological Survey, has just been completed. The first State to suggest co operation was Massachusetts, which appointed a commission consisting of General Francis A. Walker, Chairman, H. L. Whiting and Professor N. S. Shaler. Work was commenced in 1884 and was completed according to agreement in 1887. The field work was performed by and under the management of the United States Geological Survey. When this Massachusetts work was commenced, it was estimated that the map would cost \$10 per square mile, for which the State appropriated one-half or \$40,000 for her 8000 square miles of territory. The work actually cost a somewhat larger sum, the United States Geological Survey paying the difference. Besides giving the State copies of the engraved map, the Geological Survey loaned the State the engraved plates from which the Commission is publishing an edition of 54,000 atlas sheets, which are now for sale at a few cents per sheet. The State of Rhode Island was mapped in 1888 by co-operation, at the estimated cost of \$10 per square mile, of which the State paid half. The survey of Connecticut was begun by co-operation in 1888, and has just been completed at a cost of about \$9 per square mile, which is \$1 less than the estimate, the difference to be returned to the State treasury. The survey of New Jersey had been partially finished under Professor George H. Cook, State Geologist, when the United States Geological Survey agreed to contribute to the expense necessary to complete it.

This work of co-operation is destined to play an important part in the future operations of the survey, as other States are now beginning to appreciate its benefits and are anxious to obtain the co-operation of the corps of trained topographers in the employ of the United States Geological Survey, to enable them to obtain at small cost and in the shortest possible period of time, accurate topographic maps of their territory. These maps have proved of great value in delineating political boundaries exactly; aiding in the planning of a system of modern highways; and in showing up in connection with the work of the geologists the agricultural and mineral value of the land.

The handsome engraved wall-map of the United States which the draughting division has been preparing for some time past, has just been received from the engraver. This map is on a scale of

forty miles to one inch, and has contours at intervals of 1000 feet in the Appalachian and Rocky Mountain ranges, and at intervals of from 100 to 500 feet elsewhere. It is engraved and printed in three colors, as are all the atlases of the survey, and is by far the handsomest and most accurate general map of the United States ever published.

The work of the Geological Division, under Mr. G. K. Gilbert, chief geologist, is being pushed over the unsurveyed portions of the United States in such manner as to continue the general study of the stratigraphic and structural geology of the country, besides studying various economic and scientific problems which are encountered in the course of the general geological work. The California Division, under Mr. G. F. Baker, is still engaged in studying the geology of the Central Sierra Nevada, the Gold Belt district. Mr. W. Lindgren is doing the field work in the central part of the area, and Mr. H. W. Turner in the extreme northern portion and in the Yosemite National Park.

In the Montana Division, Mr. Arnold Hague, who is in charge, is engaged on working up the general problems and results of the Yellowstone Park survey. Mr. J. P. Iddings is working up the volcanic rocks of the Yellowstone Park and vicinity, and Mr. Walter Harvey Weed the stratigraphic and structural geology of the Yellowstone valley, besides studying the mineral resources of that region. Doctor A. C. Peale is engaged in studying the stratigraphic and structural geology of the Madison valley in Montana.

The members of the Rocky Mountain Division, under charge of Mr. S. F. Emmons, are completing monographs on the Silver Cliff, Ten Mile and Denver mining district, and on the Anthracite coal-deposits of the Gunnison country. Professor Van Hise is engaged on the study of the Algonkian system of Pre-Cambrian stratified rocks, the new series of rocks which is found in various parts of the United States, but is especially prominent in the Lake Superior region. Doctor White and Mr. Lester F. Ward are continuing their studies of the history of the Laramie group, the latter being engaged exclusively on the palæontology of this group. Mr. C. D. Walcott is continuing his studies of the Cambrian system.

In the east, Professor Shaler is studying the geology of the North Atlantic coastal plain, and Mr. McGee, with the aid of Mr. Darton, is studying the geology of the coastal plain at large. The

Appalachian Division, under Mr. Bailey Willis, are studying the stratigraphic and structural geology of the Palæozoic rocks in the southern Appalachian Range. Mr. I. C. Russell, who has just returned from a trip to Mt. St. Elias, in Alaska, is engaged in reporting on the geological and glacial phenomena of that region.

In addition to the routine work of the division of chemistry in making the necessary analyses for the geologists, the various chemists are engaged in doing an unusual amount of research and experimental work. Dr. F. W. Clark, the chief chemist, is engaged, with the aid of Dr. Schneider, in making a series of experimental analyses of the silicates and in investigating the colloids. Dr. Hillebrand is working on the Uranium minerals, and Dr. Chatard on the Florida phosphates, and will soon go to Florida to make field investigations and collections, in connection with Mr. Eldridge, who is studying the geology of the phosphate deposits. Drs. Melville and Eakin are both working independently on a variety of mineralogic and crystallographic analyses and experiments, while Dr. Stokes is engaged on a revision of the silicic ethers.

In the physical laboratory, Dr. Carl Barus is engaged in making experiments on high pressures and their relation to the boiling and melting points, in continuation of his former work in kindred lines, and Dr. Hallock is experimenting on the coefficient of expansion and the module of elasticity of rocks. This division of the survey has in the past issued several valuable bulletins, embodying the results of special experimental work in chemistry, and have yet more interesting volumes in preparation.

It is the intention of the director to make a brilliant exhibit of minerals at the World's Columbian Exposition at Chicago, and the work of collecting will soon begin. The survey will be glad to acquire fine specimens of typical American minerals for this purpose.

ABSTRACTS.

ANALYTICAL CHEMISTRY, BY E. WALLER.

Obtaining Iodine free from Chlorine. Musset (*Pharm. Centr.* [N. F.], xi., 230). Heat the iodine in a beaker with concentrated solution of KI until the haloid fuses; drain, wash, and dry.

Lakmoid. Förster (*Zts. f. Angew. Chem.*, '90, Heft 6) finds that the article usually sold for laboratory use contains impurities which interfere with its use, among others a substance which, though turning red with acid, is rendered *permanently* blue by alkalis. A good way of obtaining a satisfactory solution from the commercial article is to extract 8 parts with 100 parts of 20 per cent. alcohol by heating over the water-bath for 15 minutes and then cooling and filtering, afterward adding an equal bulk of alcohol. The addition of a little malachite green (about one-sixth), allowing to stand and filtering, gives a more satisfactory indicator.

Standardizing Alkalimetric Solutions. Heidenschein (*Pharm. Rundschau.*, viii., 133) recommends $\text{KHC}_4\text{H}_4\text{O}_6$ for this purpose, since it contains no water of crystallization, is not hygroscopic, and can be readily dried, withstanding a moderately high temperature without alteration. Hart and Croasdale propose (*Jour. Analy. and Chem.*, iv., 424) to electrolyze a convenient amount of pure CuSO_4 , to weigh the Cu and use the solution, which will contain 98 parts pure H_2SO_4 to every 63 of Cu found, and with this to standardize.

Potassium in Soils. Raulin (*C. Rend.*, cx., 289). The method depends upon the comparatively slight solubility of potassium phosphomolybdate. The reagent is prepared by dissolving 100 gms. neutral ammonium molybdate in water and adding 6.5 gms. pure ammonium phosphate. Aqua regia is added, and the solution digested hot, with frequent additions of aqua regia, until the precipitate is redissolved. It is then evaporated to dryness, and the residue taken up with 400 cc. of water and 5 cc. HNO_3 , heated and filtered. A liquid for washing is prepared.

A portion of the soil, which should contain the equivalent of about 0.015 grm. K_2O is weighed off, the potassium salts extracted and separated by some convenient methods from the most of the lime, iron, etc., and converted to nitrate. The solution is concentrated, acidulated with nitric acid, the phospho-molybdate reagent added in the proportion of about 4 cc. for every 0.01 grm. K_2O supposed to be present, evaporated to dryness at 50° , filtered, and washed with the washing-solution, using counterpoised filters. The precipitate contains 5.2 per cent of K_2O .

Qualitative for Alkaline Earths. Ludeking (*St. Louis Acad. Sci.*). Alkaline chromate is a more delicate test for Ba than CaSO_4 solution.

The presence of Ca or Sr salts decreases the delicacy of both tests, more particularly that with CaSO_4 . The CaSO_4 test for Sr is more affected by Ca than by Ba salts. No satisfactory method for precipitating Sr free from Ca (if present) has yet been found. The scheme recommended for qualitative detection is to precipitate the Ba from a boiling solution slightly acid with acetic by mono- or dichromate. Test the filtrate spectroscopically for Sr. Precipitate by ammonium carbonate, dissolve in as little HCl as possible, and add H_2SO_4 to precipitate all Sr and some Ca. In the filtrate make tests for Ca.

Separation of Baryta from Lime. R. Fresenius (*Zts. Anal. Chem.*, xxx., 18). In a solution somewhat acid with acetic, alkaline chromate separates the Ba with fair accuracy. By double precipitation,—resolution in nitric acid, dilution, adding ammonium acetate and then chromate, filtering, etc., very exact results were obtained. The hydro-fluosilicic acid separation of Ba gave results a little too high. By a modification of the same, which the author calls the "combined method," correct results were attainable.

Ferro-Aluminum and Aluminum Steel. Ziegler (*Dingl. Polyt.*, cclxxxv., 526). Of the finely-divided sample, 0.5 to 1 gm. is fused with NaHSO_4 . After extracting with hot water (and testing the residue with HFl to be sure of complete decomposition), washing finally with weak HCl (1 per cent.), the iron is reduced with hypophosphite and the alumina precipitate by ZnO. After filtration, the precipitate is dissolved in HCl, precipitated with ammonia, and this again redissolved and reprecipitated. It may be advisable to fuse this precipitate with Na_2CO_3 , and in the water solution from this fusion, to precipitate the Al by CO_2 , dissolve in HCl and reprecipitate with ammonia.

Estimating Copper as Cuprous Sulphide. Uhl (*Berichte*, xxiii., 2151) finds that on igniting CuS , mixed with S in a Rose crucible in a current of H, gives more or less metallic copper, and hence, estimations made in this way give incorrect results.

Antimony in Alloys. Von Bylert (*Berichte*, xxiii., 2968). A three-necked Woulff bottle is used. To one neck is attached a CO_2 apparatus, that the operation may be conducted in a non-oxydizing atmosphere. To another is attached a CaCl_2 tube, and the hard glass tube, as in the Marsh apparatus. The centre neck is provided with two tubes, one for the introduction of the material, the other for H_2SO_4 .

0.5 gm of the alloy is dissolved in 20 cc. of mercury and introduced. Then 100 c.c. of H_2SO_4 (1:10) is run in, the air present is expelled by CO_2 and the Marsh tube heated to redness. Then sodium amalgam (5.5 grammes Na in 25 cc. Hg) is run in. The evolution of H and SbH_3 is encouraged by a shaking and warming.

The Sb which collects in the Marsh tube is finally weighed as such.

Determination of Tin and Antimony. Warren (*Chem. News*, lxii., 216). The material (slag, ore, etc.), in powder, is fused with ten times its weight of Na_2CO_3 and one of borax. The melt after cooling is dissolved in HCl. After making up to a known bulk, an aliquot portion

is drawn off, precipitated with H_2S , and the sulphides treated with strong NaOH solution. This solution is divided into equal portions. In one, Sb is separated by Clarke's oxalic acid method, and finally weighed as Sb_2O_3 . In the other the sulphides are precipitated, converted to Sb_2O_3 + SnO_2 and weighed. The difference gives SnO_2 .

Distinguishing As and Sb Spots (Marsh test). Deniges (*Comptes Rend.*, cxi., 824). Dissolve in a few drops of HNO_3 , heat and add a little molybdate solution. After a short time arsenio-molybdate crystals separate, readily recognized by their insolubility in nitric acid, their color and their stellate grouping when examined by the microscope.

Delicate Reaction for Arsenic. Fluckiger (*Arch. Pharm.*, ccxxvii., 1). AsH_3 , evolved as in the Marsh apparatus, when brought in contact with a paper moistened with concentrated AgNO_3 solution, colors the spot yellow, from formation of $\text{Ag}_3\text{As} \cdot \text{AgNO}_3$, turning black by addition of water. PH_3 gives a yellow spot of similar composition and reaction. H_2S also gives a yellow spot, which is, however, not changed by water. SbH_3 gives a substance similar in composition, $\text{Ag}_3\text{Sb} \cdot \text{AgNO}_3$. The spot is usually white or light-gray in the centre, and black on the edges only. On addition of water or ammonia, it becomes black. The reaction will detect 0.005 MgAs if the evolution of gas is not too rapid. Twice that amount is stated to be the limit of delicacy of the Marsh test. For evolving hydrogen, sodium amalgam is preferred. The author found that commercial magnesium contains arsenic.

Volumetric for Tellurium. Brauner (*Proc. Lond. Chem. Soc.*, Dec., 1890.) The tellurium compound, which should contain the —ous form, is digested with HCl and SnCl_2 , and the excess of the latter then determined by iodine and thio sulphate. The reaction is $\text{TeCl}_4 + 2\text{SnCl}_2 = 2\text{SnCl}_4 + \text{Te}$.

Another method involving the oxidation of tellurous to telluric oxide by standard dichromate, and subsequent titration of the excess of dichromate by ammonium ferrous sulphate, was found to be less satisfactory.

Detection of the Halogens. Deniges (*Bull. Soc. Chim.* [3] iv., 481.) If a rod moistened with caustic potash or soda is brought in contact with gaseous Cl , Br or I , and is then dipped into an aqueous solution of aniline, colors are developed—canary-yellow with I , orange-yellow with Br , and violet with Cl . I interferes with the test for Br , the colors being so nearly alike, and both I and Br mask or prevent the Cl reaction. I may be detected by adding to the liquid (about 1 cc.) 20 or 30 drops conc. H_2SO_4 , followed by solution of K_2CrO_4 and testing the vapors with starch paper. On boiling and blowing out the vapors, the aniline test for Br may be applied, and after removing that by boiling and blowing out, some permanganate solution may be added, and the aniline test for Cl applied.

Determining Iodine. Lebeau (*C. Rend.*, cx., 520). In a flask of about 200 c.c. are placed 30 or 40 c.c. CS_2 , an equal bulk of distilled water

and a known volume of the solution to be examined. A few drops of indigo solution are then added, and standard bromine water run in from a bottle, the mixture being stirred. The iodine set free dissolves in the CS_2 . As soon as the iodide is all decomposed, the excess of Br bleaches the indigo. The bromine water requires standardizing frequently.

Sulphur in Commercial Copper. Phillips (*Chem. News*, lxii., 239). Ten gms. are dissolved in pure strong HNO_3 , the solution evaporated to dryness, taken up with moderately dilute HNO_3 and filtered if necessary. After dilution to 800 c.c., the solution is warmed to 70°C ., a little HCl added, and after stirring allowed to stand in a dark place to deposit AgCl . After filtration, the solution is evaporated twice or more with HCl to remove HNO_3 ; and finally, in a bulk of about 700 c.c. not very strongly acid with HCl , BaCl_2 is added to the hot solution, which, after stirring, is allowed to stand for twenty-four hours.

Sulphur in Gas. Ilosvay (*Bull. Soc. Chim.*, [3] iv., 714). An incomplete combustion of illuminating gas converts to H_2S the sulphur previously existing therein in some other combination. The same change occurs if the gas is passed through a tube containing asbestos and heated to $355\text{--}360^\circ \text{C}$. (dull red).

Paper impregnated with lead acetate, if placed in a tube connected with that containing asbestos, shows the reaction promptly. It is best to interpose between the two, a washing-bottle with a plug of cotton at the exit.

Silicon in Iron. Clerc (*Zts. Angew. Chem.*, 1890, 49) warms 1 gm. of the iron with 15 to 20 c.c. water, 8 c.c. Br. and 75 c.c. HCl . After solution is effected, he dilutes with 200 to 300 c.c. of hot water, filters, washes and weighs.

Determining Silica in Silicates. Gilbert (*Technol. Quarterly*, iii., 61). In slags, etc., after fusion with alkaline carbonates, dissolving in HCl and evaporating when much CaO and little MgO was present, the heat of the water-bath was sufficient to separate SiO_2 completely. Heating to higher temperatures tended to give higher results on account of adhering impurities. In presence of MgO , 120°C . was found to be the best temperature for drying, bases being partially retained by the silica at higher temperatures. CaO seemed to have but little tendency to combine with the SiO_2 during the drying, whereas, MgO tended to do so readily.

Carbon in Iron and Steel. Langley (*Am. Inst. Min. Eng., Pittsburgh Meeting*, October, 1890). It has been proposed to prepare a set of samples of steel, which should be analyzed with extreme care, which might serve as standards to which scientific and commercial analysis of iron and steel could be subsequently referred. Previous to work upon the "International Standards," it was deemed best, by the American Committee, to make some experiments with materials called for convenience "experimental standards." The results thus far reported (informally) as to carbon determinations are in effect that combustion in

a stream of purified oxygen with suitable precautions is sensibly accurate. If the carbon contains Cl, the combustion tube should contain a coil of metallic silver, and a solution of silver (preferably Ag_2SO_4) is *essential* in the purifying train. The chromic acid method will burn all the carbon. If Cl is present, some deoxidant (Pyro. with $\text{K}_2\text{C}_2\text{O}_4$) is necessary in the purifying train, otherwise much Cl may pass through an Ag_2SO_4 solution in a combination not capable of being absorbed. The Ag_2SO_4 solution should be placed *after* the deoxidizing tube. The use of a little HCl together with the ammonium copper chloride, gives higher results than when a neutral solution is employed for dissolving the iron. It seems probable that the most, if not all, of the ammonium copper chloride used, contains carbon in some form. Repeated recrystallization seems to remove some, but it is uncertain whether all is removed. Drying the carbon at temperatures above 100°C . causes a loss of C.

Nitrogen by Soda Lime Combustion. Berthelot (*Bull. Soc. Chim.* [3], iv.). By conducting the combustion in a current of purified hydrogen, the destruction of ammonia, by oxidation from the air in the tube, or manganates in the soda-lime, is avoided.

Nitrates or Chlorates by Iodometry. DeKoninck and Nihoul (*Zts. Angew. Chem.*, 1890, 477). Air being excluded by a stream of CO_2 , HCl gas is passed into the solution, which causes an evolution of chlorine, $3\text{HCl} + \text{HNO}_3 = \text{NO} + 2\text{H}_2\text{O} + 3\text{Cl}$ or $6\text{HCl} + \text{KClO}_3 = \text{KCl} + 3\text{H}_2\text{O} + 6\text{Cl}$. The chlorine evolved is passed into solution of KI and the iodine titrated.

Quantitative for Nitrates in Water. Thresh (*Chem. News*, lxii., 203) revives the use of KI and starch for this purpose. The solutions used are:

1. *Starch and Iodide.*—Starch 0.2 gm. diffused in 10 c.c. water, then add 1 gm. KOH; dissolve without heat, add 2 gms. KI and dilute with water to 200 c.c.

2. *Dilute Sulphuric Acid.*—One volume H_2SO_4 to three volumes water.

3. *Sodium Nitrite.*—0.493 gm. in 1 litre of water. 1 c.c. = 0.1 mgN. Shake some of the water in a flask so as to saturate it with air, pour 50 c.c. into a Nessler cylinder and add 1 c.c. each of solutions 1 and 2. If a blue color develops instantly, the water contains over one part per million of nitrous nitrogen and must be diluted. If it requires a few seconds to develop the color it contains less. By diluting measured quantities of No. 3 (diluted ten times) to known bulks, a series of comparison colors can be obtained; these should contain 0.05 to 0.1 nitrous nitrogen in 50 c.c. Ten or fifteen seconds is sufficient for the development of the color. Water free from nitrites and shaken with air must, of course be used in the dilutions.

MINERALOGY, BY A. J. MOSES.

ANTHOCHROITE AND VIOLAN.

Schluttig's analysis of violan is substantially identical with that of Igelström's anthochroite, and, in spite of certain optical differences,

Igelström claims their identity to be established, and that the name anthochoite should have the preference.—*Neues Jahrb.*, 1890, Bd. ii., 270.

ANTHOPHYLLITE.

Found at Jenks Corundum Mine, Franklin, Macon county, N. C., in very pure state, as fine, lustrous, transparent crystals of a delicate clove-brown color, imbedded in green foliated penninite.—*Amer. Journ. Sci.*, xl., 394.

AURICALCITE.

Penfield concludes, from examination of pure material from Beaver county, Utah, that the formula of Böttger, $2\text{RCO}_3 \cdot 3\text{R}(\text{OH})_2$, in which $\text{R} = \text{Zn}$ and Cu , is correct.—*Amer. Journ. Sci.*, xli., 106.

CALCITE.

Sansoni describes the crystallization of calcites from several localities in Norway and Sweden.—*Giornale di Mineralogia*, vol. i., pp. 129–138.

G. Cesara describes crystallization of calcite of Rhisnes.—*Giornale di Miner.*, vol. i., p. 171.

L. V. Pirsson describes remarkable crystals from Guanajuato, Mexico.—*Amer. Journ. Sci.*, xli., 61.

CASTANITE, *Darapsky*, $\text{Fe}_2\text{S}_2\text{O}_9 \cdot 8\text{H}_2\text{O}$. *Monoclinic*.

Another oxysulphate of iron from Chili, closely related to amaranite and hohmannite, is described as follows:

Occurs in coarse prismatic crystals, rarely with distinct faces, upon olive-green copiapite, associated with hohmannite and amaranite, $\text{H} = 3$; $\text{G} = 2.18$; lustre, vitreous; color, chestnut-brown; streak, orange; Translucent; practically insoluble in water; with difficulty soluble in HCl ; unalterable in the air or under desiccator. Named from Kastanie, chestnut.—*Neues Jahrb.*, 1890, Bd. ii., 267.

COLUMBITE of Black Hills, Dakota.—*Amer. Journ. Sci.*, xli., 89.

CRYOCONITE (So-called "Cosmical Dust").

This name was given by Nordenskiöld to the transparent grains of the powder which he found covering the surface of land-ice in Greenland. The crystalline form of these was said to be monoclinic, and the formula $2\text{RSi}_2\text{O}_6 \cdot \text{Al}_2\text{Si}_2\text{O}_9 + \text{H}_2\text{O}$. Later v. Lasaulx found the material to be essentially a gneiss, and to consist principally of quartz and mica, with also feldspar, hornblende, magnetite and garnet. E. A. Wülfing now states that the mixture is mainly feldspar, quartz, mica and hornblende; that feldspar is the chief constituent, then quartz up to 15 per cent., then much smaller amounts of hornblende and mica. Accessories are, rhombic pyroxene, magnesian garnet, zircon, and magnetite. The intermixed organic material, which is sometimes 5 per cent. of the entire powder, contains nitrogen and a slight amount of humic acid.—*Neues Jahrb.*, 1890, Beilage vii., 153.

DYSANALYTE.

Analysis of so-called perovskite of Magnet Cove, Arkansas, by F. W. Mar, show nearly 10 per cent. of Nb_2O_5 , Ta_2O_5 , and necessitate the classing of the mineral with Knop's dysanalte.—*Amer. Journ. Sci.*, xl., 403.

EUCOLITE.

According to Brögger, all those crystals which have the form of eudialyte and essentially its composition, but show *negative* double refraction in place of *positive* are "to be considered eucolite." It appears, that the yellowish-brown crystals of Magnet Cove, Ark., are to be classed under this head.—J. F. Williams in *Amer. Journ. Sci.*, xl., 457.

FOWLERITE (*Rhodonite*).

L. V. Pirsson publishes results of crystallographic and chemical examination of the zinciferous rhodonite; the results do not show any definite ratio between the isomorphous bases present, or any marked deviation in crystal angles from the normal type.—*Amer. Journ. Sci.*, xl., 484.

HAUERITE.

The new find of this rare manganese sulphide, at Raddusa, Sicily, is described by E. Scacchi, in *Giornale di Mineralogia*, vol. i., pp. 187-189.

HEINTZITE and HINTZEITE.

Independently, certain crystals occurring in lumps of pinnoite from the vicinity of Stassfurt, are described under these names. The differences may be judged from the following summaries:

HEINTZITE. *Luedecke. $\text{H}_2\text{KMg}_8\text{B}_{11}\text{O}_{30}$. Monoclinic.*

In gypsum-like crystals, $\beta = 57^\circ 41'$, $a : b : c :: 1.2912 : 1 : 1.7572$, $H = 4$, $G = 2.129$. Clear and transparent. Melts very easily, coloring the flame green. Easily soluble in HCl or HNO_3 . Analysis shows: B_2O_3 , 60.53; MgO , 12.23; K_2O , 7.39; H_2O , 19.85.

Named after Herr Heintz, a chemist of Halle.—*Zeit. f. Kryst.* xviii., 481.

HINTZEITE. *L. Milch. $\text{H}_4\text{Mg}_8\text{K}(\text{BO}_2)_9 + 6\text{H}_2\text{O}$. Monoclinic.*

In monoclinic crystals, $a : b : c = 2.1937 : 1 : 1.73385$, $\beta = 80^\circ 12'$, $H = 4.5$, $G = 2.127$. Colorless or cloudy white. Fuses easily to white enamel. Easily soluble in HCl . Analysis shows: B_2O_3 , 52.39; MgO , 13.80; K_2O , 8.14; H_2O , 23.83; Na_2O , 0.39; Cl , 0.35.

Named after Professor Hintze, of Breslau.—*Zeit. f. Kryst.*, xviii., 478.

HEMATITE.

The grains of the Clinton oölitic iron-ore, instead of being spherical *concretions*, are found, by A. F. Foerste, to frequently show the structure of bryozoans and fragmental remains of the same, and to vary in size and shape with the character of the species from which they are formed. Generally, the iron has replaced the substance of the bryozoan, and also the cement which binds the grains together. In some cases, the lime-

cement has been but slightly altered; at other times, the lime of the bryozoans is little altered, while the lime of the cement which filled the cells is replaced by the iron-ore.—*Amer. Journ. Sci.*, xli., 28.

Crystallization of Hematite of Stromboli, described by G. Strüver.—*Giorn. di Mineral.*, vol., p. 159.

LEADHILLITE.

The crystallization of Sardinian leadhillite is elaborately described, and illustrated, with numerous references, by E. Artini, in *Giornale di Mineralogia*, vol. i., pp. 1-29.

LEVERRIERITE.*

M. Termier further describes the mineral and gives as the formula, $H_{10}Al_4Si_3O_{21}$, not far from pholerite.—*Bull. Soc. Franc. Min.*, xiii., 325.

MANGANPECTOLITE. *J. F. Williams*. $(\frac{9}{10}Ca \frac{1}{10}Mn)NaHSi_3O_7$. *Mono-clinic*.

This name has been given to a new zeolite, evidently a decomposition product of *Ægirite* and the other manganiferous minerals of the *elæolitic syenite* of Magnet Cove, Arkansas.

It occurs in tabular crystals, the largest of which are 20 x 10 x 6 mm. in size, which show the three pinacoids and a dome. $a:b:c::1.0731:1:0.4840$. There is an easy cleavage parallel to the base. $H=5$; $G=2.845$. Lustre, pearly to silky on cleavage; transparent, but with outer crust of brown, opaque material. Before the blowpipe the powder becomes rose-red, then melts with difficulty to a rose-red glass. Soluble easily in HCl, but, after fusion, soluble only slowly with a residue of pulverulent silica.

Analysis shows: SiO_2 , 53.03; Fe_2O_3 , 0.10; CaO , 30.28; MnO , 4.25; Na_2O , 8.99; H_2O , 2.43; CO_2 , 0.82.

Is separated from pectolite chiefly by the manganese contained. Hence the name.—*Zeit. f. Krist.*, xviii., 386.

MELANOPHLOGITE. $SO_3, 20SiO_2$.

M. G. Friedel has made a careful re-examination of this interesting mineral, and his conclusions differ decidedly from those of Mallard, Pisani and others.

Chemically, he states it to be a true combination of sulphuric anhydride and silica, in the proportion $SO_3, 20SiO_2$.

Crystallographically, he finds it to be a special case of pseudo-symmetry, and not to be pseudo-morphic. The more perfect cubes show, in natural light, an infinitude of concentric cubic zones of growth, and the cubic diagonals are clearly marked; under polarized light the diagonals are more clearly marked, dividing the cube into six quadratic pyramids, which converge towards the centre of the cube and have the faces of the cubes for bases. Each cube face is found to be two planes intersecting in a diagonal, and making an angle of 178.48 with each other. The pyramids are doubly refracting, the sign of each being positive with reference to the particular cube axis traversing the pyramid. No

* See this Journal, vol. xii., p. 70.

cubic cleavage was observed. Finally, the fibres noticed by M. Mallard in the spherical groups are each divided, under polarized light, into two fibres of different colors, showing them to be only the intersection of the numerous crystals possessing a common centre.—*Bull. Soc. Franc. Min.*, xiii., 356.

PINAKIOLITE, *Flink* (MgO), B_2O_3 , $MnO.Mn_2O_3$. *Orthorhombic*.

A mineral related crystallographically and chemically to ludwigite has been found at Langban, Sweden, in thin parallel stripes and bands in granular dolomite, associated with hausmannite, tephroite, manganophyllite, berzelite, etc.

It occurs in minute tabular crystals, usually very much broken, which show only $\infty P\infty$ and ∞P_3 , and in crystals twinned parallel to a dome. The ratio $a:b:c = 0.83385:1:0.5880$ is calculated. Cleavage is parallel to $\infty P\infty$. $H = 6$; $G = 3.881$; lustre, strongly metallic, dull on prism, bright on pinacoid; color, pure black; streak, brownish-gray.

Before the blowpipe the powder becomes black and melts with difficulty to a black non-magnetic slag. Soluble in HCl with evolution of Cl. Analysis shows: B_2O_3 , 15.65; MgO , 28.58; Mn_2O_3 , 49.39; Fe_2O_3 , 2.07; CaO , 1.09; PbO , 0.76; SiO_2 , 1.21; H_2O , 0.47.

Named from *πίναξ*, a little table.—*Zeit. f. Kryst.*, xviii., 361.

POWELLITE,* *W. H. Melville*, $Ca(Mo,W)O_4$. *Tetragonal*.

Found at Peacock claim, "Seven Devils," Idaho, associated with massive lime garnet and bornite.

Crystals pyramidal, showing base and sometimes the prism, $a:c = 1:1.5445$. In habit closely allied to scheelite. $H = 3.5$; $G = 4.526$; lustre, resinous; color, greenish yellow; semi-transparent; brittle.

Fuses with difficulty to a gray mass; is decomposed by HCl or HNO_3 . Analysis showed MoO_3 , 58.58; WO_3 , 10.28; CaO , 25.55; SiO_2 , 3.25; Fe_2O_3 , 1.65, etc.

Named after Major J. W. Powell, Director of U. S. Geological Survey.—*Amer. Journ. Sci.*, xli., 138.

PYRITE.

Crystals from three Italian localities, illustrated and described by G. Boeris.—*Giorn. di Mineral.*, vol. i., 103-107.

REALGAR AND ORPIMENT.

Occurrence at Teste, Mt. Amiata, recorded by G. Grattarola, in *Giornale di Mineralogia*, vol. i., 232.

SANGUINITE, *Miers*.

A probable hexagonal sulpharsenite of silver allied to proustite, but occurring upon the argentite of Chañarcillo, in fine glittering scales or plates of a dark bronze-red color, resembling the pyrrhosiderite of Siegen.

Lustre, like earthy hematite; color, bronze-red by reflected light,

* See Scheelite.

blood-red by transmitted light; streak, dark purplish-brown.—*Min. Mag.*, ix., 182.

SCHEELITE.

In connection with the new species, powellite, is to be noticed the analyses of H. Traube, in which molybdic acid is found in Scheelite, replacing the tungstic acid.

Zinnwald, Saxony, 1 CaMoO_4 with 8, 20 and 40 CaWO_4

Altenberg, 1 CaMoO_4 " 40 CaWO_4

Pot Mine, S. Africa, 1 CaMoO_4 " 8 CaWO_4

Other localities showed small amounts of molybdate.—*Neues Jahrb.*, 190, *Beilage*, vii., 232.

TANTALITE, of Black Hills, Dakota.—*Am. Journ. Sci.*, xli., 98.

TRIMERITE, Flink, $\text{Be}(\text{Mn}, \text{Ca}, \text{Fe}, \text{Mg})\text{SiO}_4$. *Triclinic*.

There has been found at the Harstig mine, Wermland; Sweden, in searching for friedelite, a mineral occurring under very similar conditions, and in one case associated with the friedelite. The author states that he at first mistook the mineral for large light-colored crystals of friedelite.

Trimerite is found enclosed in later-formed calcite crystals, upon a granular mass of magnetite, pyroxene, garnet, etc., and immediately surrounded by hair-like grammatite. The crystals are small and pseudo-hexagonal, somewhat resembling willemite in form, but optically are found to consist of three trichinic individuals, whence the name, from *τριμερής*, divided in three. Cleavage parallel to base.

H = 6—7; G = 3.474; lustre, bright vitreous; color, salmon or pale yellowish-red to colorless; not usually perfectly transparent; fracture, conchoidal. Before the blowpipe, fuses with difficulty to a dark slag. Is decomposed by HCl, with separation of flocculent silica. Analysis shows: SiO_2 , 39.77; BeO , 17.08; MnO , 26.86; FeO , 3.87; CaO , 12.44; MgO , 0.61.—*Zeit. f. Kryst.*, xviii., 365.

URANINITE.

Dr. W. F. Hillebrand, from chemical examination of the uraninite of several localities, reaches the conclusions: that nitrogen exists in an unknown condition in uraninite in quantities up to over 2.5 per cent., and seems to bear a relation to the amount of UO_2 present; that the uraninite of different localities differ widely in composition and physical characteristics, and that the formulæ of Comstock and Brögger are inapplicable to such varieties as Bröggerite, Cleveite and Nivenite.—*Amer. Journ. Sci.*, xl., 384.

APPARATUS.

Bartolini and Grattarola describe with illustrations convenient modifications of laboratory apparatus for measurement of indices of refraction, measurement of angles, polarization, specific gravity, conductivity of heat, etc.—*Giornale di Mineralogia*, vol. i., 113-128.

BOOK REVIEWS.

SUGAR ANALYSIS. For Refineries, Sugar Houses, Experimental Stations, etc., and as a Handbook of Instruction in Schools of Chemical Technology. By F. G. Wiechmann, Ph. D. New York. 1890.

The author's position as instructor in chemical philosophy at the School of Mines and his wide experience as chemist to several of our most advanced sugar refineries have admirably combined to enable him to lay before his readers a work of marked value and clearness, of great use to students and chemists interested in the many branches of sugar analysis. Clearness and brevity mark the book, while its arrangement of subject-matter is most rational and convenient. Starting with the various instruments used, the polariscope is considered from both theoretical and practical standpoints, cuts being given representing the optical parts of the Soleil-Ventzke-Scheibler color instrument and of the Schmidt and Haensch half-shade instrument with double wedge compensators. The directions for testing and adjusting polariscopes, a matter of paramount importance, are clearly given.

Hydrometers of the varieties they receive minute attention, with information as to their manner of graduation, limits of error and the principles involved in their use. The directions for graduation of flasks in true and in Mohr cubic centimetres deserve close attention, as errors are so apt to creep in just here.

Next we find described the manner of sampling molasses and syrups as done for the refinery and for the government, and the method of determining the colors of sugars and the colors and densities of solutions.

The determination of sucrose when unaccompanied by other optically active bodies, is a simple matter, and the methods, with all necessary precautions, are concisely given, including what is so important in refineries—the quotient of purity or exponent of liquors, syrups, sweetwaters, etc. Of the different methods, Cassamajor's is that almost exclusively employed. A table is given of factors, corresponding to different degrees of density of sugar solutions, by which the polarization is to be multiplied to give the exponent.

In a refinery laboratory, it is well to have also a table of products of factors corresponding to the different degrees and tenths of density by the possible degrees and tenths of polarization, so that the exponents may be found at once without calculation.

The gravimetric determination of sucrose is accompanied by a table rendering calculation very simple.

The determination of different optically active substances when occurring together is more difficult and is considered in several chapters, which are replete with the latest and best methods, containing evidences of much good work by the author. In Clerget's method of inversion and polarizing, the constant 142.66 is used for the calculation in lieu of the old constant 144. In this method the direct as well as the indirect polarization should be made at 20° C. to secure the best results.

The interesting question of Raffinose receives merited attention,

formulas being given for calculating its percentage, as well as examples and a valuable list of references. Optical and gravimetric methods for mixtures of sucrose and dextrose and of sucrose, dextrose and lævulose are accompanied by important researches by the author, already published in the *SCHOOL OF MINES QUARTERLY*, April, 1890. The latter methods will find more frequent applications in scientific than in technical laboratories.

Invert sugar is considered separately. The success of this determination depends so much on an exact observance of minutiae that one is pleased to find the details of Fehling's method carefully presented.

A long description of the gravimetric method is given, with examples, accompanied by a table of factors to be used, as the proportion of Cu_2O , precipitated by the invert sugar, depends upon the ratio of sucrose to invert sugar in the solution.

A method for invert sugar in presence of other reducing bodies is an important item.

The preparation and use of Soldaini's solution are described, though this reagent has not met with general favor.

The author recommends drying sugars in *vacuo* to save time.

The usual deduction of one-tenth from the weight of the sulphated ash is incorrect when applied to cane sugars, as the author has shown, but this is an empirical method which must be adhered to for the present. In the discussion of organic non-sugar, extensive schemes are given for the separation of the many organic acids which may occur in sugars.

A subject which will be of especial interest to refiners is that of the conclusions to be deduced from the analysis of molasses. A list is given of the methods of calculating the rendement, from the analysis, used in different countries.

The author presents a full table of synonymous names in English, French and German of the different sugars and a long list of monographs on, and periodicals relating to, sugar.

The volume closes with a collection of nineteen tables for use in facilitating calculations in sugar analysis, and providing much valuable information pertinent to the subject. They are quite a feature of the book, and will prove a great attraction to chemists busied in this department.

The whole work is characterized by clearness, and nearly every principle is illustrated by an example fully explanatory. The use of the word "sucrose" to designate the ordinary cane sugar is very good, as all ambiguity of terms is thus avoided.

One is led to regret that no mention is made of bone-black nor certain laboratory tests on char washings, etc. But the book has purposely been kept small, and it certainly is an admirable treatise, to be highly recommended to refiners, chemists, students and all who are interested in the analysis of sugar.

W. D. HORNE.

New Brunswick, N. J., Dec. 1, 1890.

BULLETIN OF ALUMNI AND COLLEGE NEWS.

DEPARTMENT OF MINERALOGY AND METALLURGY.

Since the last Bulletin, 300 specimens have been added to the mineral collection of the school. A number of beautiful specimens of chalcotrichite from Arizona have been received and exchanged. Five beautiful specimens, illustrating nearly all the forms of hauerite, have been received. A number of application-goniometers have also been purchased, and a large goniometer has been received, which, it is hoped, will be presented to the school.

With the exception of a very valuable specimen of crystallized argente presented by Mr. Robert Mulford, of the Class of '84, there have been no presentations to the collection nor additions made to it from graduates. It is hoped that they will in the future be interested in collecting crystallized specimens to present to the collection. Some very valuable additions have been made by presentation from graduates in the past, and it is hoped that it will be continued.

The Catalogue of Mineral Synonyms prepared under the direction of Dr. Egleston and printed by the United States National Museum has been very favorably received. The following is from *Bulletin de la Société Française de Mineralogie*, December, 1890, vol. xiii., p. 404:

"This very complete catalogue, of 198 octavo pages in two volumes, gives the list of all the mineral pieces (in capitals, doubtful species in italics), with their synonyms (in ordinary type). Each species is followed by its chemical formula and the name of its crystalline system. Most of the species are followed by the indication of the author who created the name cited. It is to be regretted that the author has left this portion of his work incomplete. This dictionary will render great service to all those who have the handling of great mineral collections."

METALLURGY.—193 specimens have been added to the metallurgical collections, a few of which await labelling. For the investigations upon slags which are going on, boxes have been received from Mr. Austin, of the Class of 1876, and from Professor Pearce, of the Boston and Colorado Works. Also slags from Laurel Hill, sent by Mr. Ferguson, of the Class of 1887. The Tiffany collection has been enlarged by the presentation of ten specimens illustrating all the stages of the manufacture of spoons; eight specimens representing the manufacture of hollow vessels by hammering, and eight others representing the same manufacture by spinning. The whole collection now makes a beautiful suite. The collection of refractory materials of Joseph Dixon & Co. has been completed, and specimens of magnesite from Eubœa have also been received. The Pelton Company, of San Francisco, have sent a two-foot Pelton wheel with a $\frac{1}{4}$, $\frac{3}{8}$ and $\frac{1}{2}$ nozzle, in full working order. Eighty diagrams of recently-constructed furnaces have been added to the collection of diagrams. Considerable investigation work is being done in the laboratory at the present time.

DEPARTMENT OF MECHANICS.

Dr. M. I. Pupin, Instructor of Mathematical Physics in the Department of Electrical Engineering, announces the following course of University Lectures "On the Principle of Conservation of Energy and its Application in Physics and Chemistry :"—

I. INTRODUCTION.

A. *On the Simplest Phenomena.*

(1) Motion of a material particle. The simplest accidents (*vide* Rankine, for the definition of the term "accidents") of a material particle, viz.: mass, velocity, momentum, acceleration, weight, *vis viva*, work. *The absolute* or mass-system, and its relation to *the practical* or weight-system of physical measurements.

(2) Motion of a connected system of material particles and rigid bodies whose condition is completely defined by masses, space co-ordinates and their differential coefficients with respect to time. (The chief aim of these considerations is to sketch briefly the historical development of Mechanics during the interval between Newton's announcement of the *Three Laws of Motion* and the discovery of D'Alembert's principle.) D'Alembert's principle and its relation to the complete demonstration of the "*Principle of Conservation of Vis Viva*." Lagrange's introduction of generalized space co-ordinates into the theory of motion of material systems. Lagrange's, Hamilton's and Jacobi's *General Dynamical Principles*. (A detailed discussion of these principles is given, because it is through these principles and the principle of conservation of energy that the application of Dynamics to Physics and Chemistry is made possible.) On the monocyclic material systems of Helmholtz.

II. *On Complex Physical Phenomena*.—On material systems whose condition cannot be completely defined by mass, space co-ordinates, and their differential coefficients. On the *general accidents* or properties of matter and the possibility of their quantitative measurement. On *Energy*, or the *most complex accident* of a material body. On the convertibility of energy and the possibility of a definition of energy based on the principle of its convertibility.

B. *On the Principle of Conservation of Energy.*

III. *Historical Development of the Principle of Conservation of Energy*, especially its connection with the historical development of Thermodynamics. (A short review of the labors of Carnot, Joule, Colding, Robert Meyer, Helmholtz, Rankine, Thomson, Clausius, Hirn, etc.) A detailed review of Helmholtz's Essay: "On the Conservation of Energy."

IV. *Formulation of the Principle and a Review of the Lines of Argument which prove it.*

V. *On the Various Forms of Energy*, viz.:—Mechanical, thermal, electrostatic, magnetic, electromagnetic, chemical and luminous energy.

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C. On the Application of the Principle of Conservation of Energy.

VI. On complex states of matter and their complete definition by means of the principle of conservation of energy. On the extended meaning of "kinetic" and "potential" energy, or the kinetic and potential energy of a complex state of matter. Validity of the dynamical principles of Lagrange, Hamilton and Jacoby in the case of complex states of matter.

VII. Application of the extended dynamical principles to the study of Physics and Chemistry. A brief review of the investigations of Rankine, Maxwell, Helmholtz and J. J. Thomson.

The course will commence about the middle of February. There will be one lecture of two to two and a half hours per week. The course is one of the University courses in the Department of Mechanics; the lectures will, therefore, be delivered in Prof. W. G. Peck's lecture-room. Day and hour will be fixed to suit the convenience of the majority of those interested in these lectures. The course will extend over three terms.

DEPARTMENT OF PHYSICS.

At the earnest request of Professor Rood, President Low has greatly increased the facilities and the space occupied by the Physical Department. The laboratory, instead of consisting of a single moderate-sized room, now occupies four rooms, one of which is quite large; the department, including lecture-room and cabinet, covering almost the whole upper floor of Hamilton Hall.

Laboratory instruction, at present, is furnished to the Third-Year Class, and to such members of the Senior Class of the Department of Arts as may desire it, as well as to Post-Graduates. In expectation of the present development, a good deal of apparatus for laboratory purposes had been acquired during the last few years, and with much that is quite new, is now being used for laboratory instruction, and the appropriation for this purpose will, no doubt, be considerably increased.

The services of Mr. Holbrook Cushman, a graduate of the Class of '78 (Arts), have been secured as laboratory instructor. Mr. Cushman, on graduation, received the prize Fellowship in Science, and, in that capacity, studied for three years in Europe, and since that time has held various positions as an electrical expert.

DEPARTMENT OF GEOLOGY AND PALEONTOLOGY.

ZOOLOGY.—A gift of \$10,000 has been received from Mr. C. H. Senff, to be used for the purchase of zoological books and apparatus, and some important additions have hence been made to the library. Among these may be noted a set of "Challenger Reports," all the Natural History catalogues of the British Museum, and a complete set of the "Zeitschrift für Wissenschaftliche Zoologie."

The Zoological collections have been increased by the following collections made by Dr. and Mrs. John I. Northrop:

1. A collection of marine invertebrates from Eastport, Maine.
2. A collection of Bahaman marine invertebrates, mollusca insects, amphibians, reptiles, and birds.

3. A collection of about 1500 local bird skins, purchased and presented by John I. Northrop.

4. A set of marine invertebrates, duplicates, presented by the National Museum.

The following additions have been made to the zoological apparatus :
One Ryder microtome, and one Zeiss dissecting lens. J. I. N.

DEPARTMENT OF ARCHITECTURE.

The first competition for the McKim Fellowship began on the evening of Monday, January 5th, when about a dozen competitors, mostly from the classes of '89 and '90, assembled to receive the programme and begin their preliminary sketches. The subject of the design is "a small museum for fifteen statues and fifteen pictures," and the preliminary sketches were handed in on Friday of the same week, the drawing being done at the school. The finished drawings, comprising a general plan, to the $\frac{1}{8}$ -inch scale, an elevation to the $\frac{1}{4}$ -inch scale, and a cross-section of the main exhibition-room to the $\frac{1}{2}$ -inch scale, are to be executed at the school during the evenings of the fortnight ending Saturday, February 21st; no work, however, being done on either Saturday. The final examination on construction and practice will occupy the evenings from March 2d to, and including March 6th; and the two Fellowships, each of \$1000, will be awarded as soon thereafter as possible by an expert jury of architects.

The competition is being conducted substantially on the lines of last year's competition for the Columbia Fellowship, but with a reduction in the number of evenings of attendance required. Experience showed that last year's requirements imposed too fatiguing a load upon the competitors, who were, in consequence, hardly able to do themselves full justice. Another innovation, is the provision for out-of-town graduates, who are allowed to take part in the competition under the supervision of some acceptable architect practicing in their vicinity. Three designs have been received under these conditions from Washington, D. C., Philadelphia, and Pittsburgh, respectively.

The Saturday evening sketch-club of the second-year architects has proved very successful. Sketches from life of members, who pose in costume by turns, and sketch-designs of architectural subjects, alternately occupy the evening, and with some very creditable results. The weekly exercises in design, which Professor Ware has conducted in the same class, have also proved both interesting and useful.

During the coming term exercises in Historical Design will form a part of the course of original study in Mediæval History under Mr. Sherman. It is also probable that "five-hour sketches" in "General Design" may form a feature of the second term's work in the third-year class, a corresponding allowance of time being granted to the fourth-year men for the execution of their thesis drawing.

A. D. F. H.

DEPARTMENT OF PRACTICAL ASTRONOMY AND GEODESY.

Dr. Rutherford presented the College in 1883 with his 13-inch refractor with photographic correcting lens, a fine transit, a Dent clock, and micro-

meters etc., in all valued at about \$20,000. These gifts he has now supplemented by turning over to the College all his original photographs of the moon, the sun and star clusters, with many volumes of measures made on the last. This collection of negatives numbers some 1600, many of which have not been measured. President Low has had shelves fixed in the fire-proof vault of Hamilton Hall, whereon to store these valuable photographs.

Unfortunately for science the plates and measures, though made twenty years ago, have been only partially reduced. Dr. B. A. Gould, in 1866 and 1870, read papers before the National Academy of Sciences on his reduction of the measures made in 1866-67 on the Pleiades and the cluster in Praesepe. He then showed that the photographic measures gave very valuable results. Dr. Gould's memoirs, however, were not printed until quite recently. The photographs made by Mr. Rutherford subsequent to 1868 were taken with his 13-inch object-glass and corrector (now in the College observatory), and the plates have been measured since 1872 with his improved micrometer, where a *glass scale* was employed, so that the micrometer screw had to be depended upon only for a distance less than ten revolutions.

None of the later measures have been reduced. The measures have been placed in the hands of Prof. Rees and Mr. Harold Jacoby, of the Observatory. Prof. Holden, director of the Lick Observatory, writes Prof. Rees: "I am very much pleased to know, from your letter of December 13th, that you have Dr. Rutherford's original negatives, and better than this, that you are reducing them. I shall put his objects on our observing list (that is, most of them), and duplicate his work, and your reductions and ours will be a valuable gift to the photography of clusters and of doubles."

IN THE MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY OF LONDON for December, 1890, appears a paper by Harold Jacoby "On the Correction of Micrometric Observations for Refraction."

This paper is one of the results of Mr. Jacoby's stay in Cape Town. The Royal Observatory at Cape Town has published the tables computed by the formulæ derived from the paper named above.

Mr. Jacoby has published, in No. 233 of the *Astronomical Journal*, a paper "On the Reduction of Astronomical Photographic Measures."

OBSERVATIONS were made with the 13-inch refractor on the faint comet e 1890 (Zona), by Prof. Rees and Mr. Jacoby. The results were published in the *Astronomical Journal*, and used in the calculation of the comet's orbit.

THE equatorial is to be supplied with a new eye-piece by Alvan Clark & Sons, arranged with ring micrometer for comet work especially.



JAMES BUCKTON MACKINTOSH.

Died April 15th. 1891.

metallic constituents rose up in a molten condition, or was driven into fissures and crevices from below, we might well conceive that the more volatile metals evaporated or were eliminated by combus-



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THE SCHOOL OF MINES QUARTERLY.

VOL. XII.

APRIL, 1891.

No. 3.

ON THE GENESIS OF ORE-DEPOSITS.

By W. H. VON STREERUWITZ.

(Geological Survey of Texas.)

It is a fact, well known among mining men that the "Gossan" of the Cornish, like the "Eiserner Hut" of the Germans, the "Pacos" and "Colorados" of the South American miner, in short iron outcrops and outblows may be regarded as very promising indications of leads, not only of ferruginous leads, but of ore-bearing leads in general.

As a rule, especially in igneous and metamorphic rocks of a siliceous character, these outcrops consist of iron-silicates, either fresh or in various stages of decomposition, and their surfaces frequently exhibit no trace of any other metal but iron; this barrenness even prevailing to considerable depths.

Now why is it that these outcrops are almost invariably composed of more or less altered iron-silicates (whether resulting from the decomposition of iron pyrites or otherwise) and why is it that, although devoid of other metals on or near the surface, they generally carry such at greater depths?

If we assume that a magma composed of metallic and non-metallic constituents rose up in a molten condition, or was driven into fissures and crevices from below, we might well conceive that the more volatile metals evaporated or were eliminated by combus-

tion from the matrix, so that only the less volatile iron-silicates remained, which afterwards underwent a process of decomposition through atmospheric agencies, sometimes giving rise to soft ochrous outcrops, such as the Almagres of the Mexicans, Eiserner Hut, Gossan, etc.

This hypothesis would not be upset by the fact that such iron-outcrops are frequently rich in other metals on or close to the surface, getting poorer at moderate depths and richer again deeper down. We could account for this by assuming that at the time when the fissures or crevices were filled they were overlaid by superincumbent rock masses, sufficiently thick and cool to condense and confine the volatile minerals in and around the ferruginous materials, in their uppermost portions, which afterwards, through denudation, became our iron-outblows.

But, accepting these premises, we would still have to explain why larger and smaller pockets, irregularly distributed in the leads, differ often so completely in character from each other, so that we find ore-deposits contrasting widely in point of volatility and density, side by side or even connected with each other by veins.

True, the original magma might have been cavernous or vesicular, so that the metallic vapors could have accumulated or condensed in already cooler parts of the fissures, but we have still to confront the greater difficulty, viz., the cause of the difference in the character of the mineral-deposits in the cavities, and why the iron-outcrops are always siliceous, whereas other metals of less affinity for sulphur occur as sulphates. Furthermore, we will have to account for the reason why pockets are sometimes very poor in iron and rich in other metals.

If, on the other hand, we assume that the fissures were filled with solutions of the different minerals, which now form the leads which are indicated by iron-outcrops, and that the gangues and leads as we find them are precipitations of the different minerals, and if we accept the hypothesis that in the wider portions of such fissures the liquids circulated slower than in the narrower ones, so that the rate of deposition was determined by the speed of the circulatory motion, we also encounter serious difficulties.

Thus, for instance, we have to consider the probability that in the fissures close to the widenings were very narrow portions and *vice versa*, so that we might well hesitate to draw conclusions in this direction from such limited knowledge as we have of ore-leads

in the whole extent of their horizontal and vertical ramifications. We also have to bear in mind that the solution which, at the time of its intrusion into the fissures and cavities, was in a highly heated condition, must have soon acquired a uniform temperature (especially in a magma protected by superincumbent rocks) so that all circulatory motion, except such as might be caused by differences in the specific gravity of the minerals held in solution, must have speedily subsided.

Now if the precipitation was due to the retardation of the circulation, we would necessarily expect the richest deposits in the widest parts of the gangues, which is not the case. If, on the other hand, we attribute the motion to differences in specific gravity, the heavier deposits would invariably be found beneath the lighter ones, which is also not the case. Besides, if the aforementioned agencies led to the formation of ore-pockets in the wider parts of the fissures, how are we to account for the fact that frequently not only superior ores, but even larger deposits, are found in narrower parts of the fissures, where according to this hypothesis they ought not to be? We also often find the heavier minerals high above, or alternating with, the lighter ones, which points against a circulation caused by differences in specific gravity. Besides, this hypothesis does not touch the question why the ores in fissures of evidently contemporaneous origin in the same rock (and to all intents and purposes derived from the same source under the same conditions) are frequently so different, qualitatively and quantitatively, as far as ore-bearing is concerned? And this difference exists not only in different leads; there are very few, if any, leads in which the ore-bearing is (even approximately) uniform in quality and quantity for even limited portions of one and the same lead.

To be short, since neither of the hypotheses hitherto advanced will afford a satisfactory explanation of the genesis of iron-outcrops, we must endeavor to solve our problem in a different manner. The current theories have been in vogue for more than three hundred years, and it would seem as if no essential progress in the philosophy of ore-deposits and vein-formation had been made since Agricola's, "*De ortu et causis subterraneorum*" (1546) made its first appearance.

If we place a piece of sulphate of iron (common copperas) into a cold, not too much diluted, solution of an alkali-silicate, it

begins to grow in thin, at first nearly colorless, threads, resembling somewhat the growth of algæ in stagnant water. These threads, when reaching the surface of the liquid, begin to oxidize and spread, and then an accumulation of ferruginous silicate is deposited, resembling that of the iron-outblows which indicate ore-veins. As far as I have yet been able to ascertain experimentally, sulphates and other salts of metals, other than iron, do not grow or develop in this manner, or if they do, the process is exceedingly slow, so that one year's progress in growth is often barely perceptible, and such growth, moreover, never tends in an upward direction. If we heat our solution, the fibres of iron-silicate grow more rapidly, and at a temperature of 70 to 90 degrees (Centigrade) the development is so quick that, in most instances, it can be followed with the naked eye. Besides this the higher temperature causes the thin, smooth and almost colorless fibres to develop into thicker strings of brown and dark-green color, bending in every direction and forming reticulations in which accumulations (pockets) are frequently observed.

Similar, though somewhat modified phenomena, are brought about by galvanic currents. In a heated solution, however, salts of lead, zinc, copper, etc., may be forced to grow upwards, but the development is slower and more irregular, and instead of slender smooth threads, irregular pockets, exhibiting every variety of outline (when different salts are used) and which are connected with each other by rough strings, are formed.

If, however, salts of other metals—not necessarily sulphates—are used together with the salt of iron, the threads of iron-silicate not only begin to grow at once but they carry along with them the other metals, so as to form veins of pure silicate of iron, or embracing other metals; sometimes widening out into pockets rich in other metals, or even without a trace of anything but iron. From such pockets sprout again veins of pure iron-ore, or miscellaneous ore-veins which again may form pockets. Gold and platinum salts (as far as my experience goes) are invariably reduced to the metallic state, silver and copper salts frequently, especially if brought in contact with hydrogen or hydro-carbon injected into the solution. By continuously admitting small quantities of sulphuretted hydrogen, ammoniac sulphide or carbon dioxide, the author succeeded in transforming some of the ore-strings into sulphides and carbonates.

In fact, there can be little room for doubt that any form of ore-vein or outcrop found in siliceous gangues may easily be reproduced on a small scale in the laboratory, in silica solutions, with the assistance of time, heat and galvanism from any given salt of a metal brought in contact with iron salts.

The author's observations were not limited to the genesis of artificial ore-veins in experimental tubes; he also studied the formation of agates in free solutions. He invariably found that the development of siliceous layers, instead of commencing with an outer zone and progressing towards the centre by a process of osmosis (as hitherto supposed), started with an acicular crystalline mass of silica as a nucleus, which then became enveloped by a thin film of silica, thickening slowly into regular agate-bands of various tints, through deposition on the surface. This phenomenon was first observed at the bottom of one of the test-tubes, which during the writer's absence in the field had been neglected for nearly two years, and in which the metallic salts (chloride of gold and sulphate of iron) were exhausted. Above the layers of agate a dendritic siliceous structure had been developed, and over this again a cloudy deposit of micro-crystalline silica, which surrounded the metalliferous fibres and extended to the end of the tube (a distance of fully twelve inches). Wherever this siliceous deposit touched the wall of the tube it showed plainly metallic gold, partly in microscopic crystals arranged in star-like groups, partly in bright lamina and symmetrical octahedrons.

The experiments here described are of course incomplete and to be regarded as a preliminary to more exhaustive inquiry. For nearly two years, during which the writer was engaged in the exploration of Trans-Pecos Texas, the test-tubes were not attended to, and since the renewal of the investigation the time has been too short for definite conclusions. Nevertheless the experiments would, so far, appear to establish the following points, viz.:

1. It is principally the iron which, in silico-ferruginous fissure-veins, brought the other metals from greater to (by mining) accessible depths.
2. Most siliceous ore-leads, carrying also large quantities of iron and having silico-ferruginous outcrops, seem to be deposited from hot aqueous solutions of the metals and silicates.
3. Metals and metal combinations contained in the rock surrounding the fissures and crevices, were probably leached out by the hot

liquids contained in the fissures and precipitated on and combined with the siliceous iron, growing up in the fissures.

4. The fissures could be charged with ore-veins in a comparatively short time, since, no doubt, high temperature and galvanic currents existed in the fissures at the time of the formation of the ore-gangues.

5. In contact-gangues the precipitation and deposition of ores was materially facilitated by galvanic currents, caused by the contact of different rocks, and it is owing to the prevalence of galvanic currents that in most cases richer deposits at the intersection of two or more leads were formed.

6. The so-called iron outblows are frequently not the product of igneous eruption, but a deposition-product from aqueous solutions, and alteration in the rocks contiguous to such outblows are not necessarily the result of eruptive agencies, but of a leaching process.

7. The formation of banded agates does not always take place (as generally believed) in the cavities of a rock, but can also occur free in solutions, and the thickness of the bands progresses from the centre outwards, although a reverse process, by osmosis, may be possible under certain conditions.

AN ASSAY FURNACE.

BY HERBERT WOOD, M.A., FELLOW, TORONTO UNIVERSITY.

THE accompanying diagram represents a muffle furnace as used in the Pueblo Smelting and Refining Company, Colorado. This furnace is one of a group of three which stand side by side, and the flue here given is the one used by the three furnaces. A flue measuring 6 inches by 8 inches is, however, quite large enough for one furnace. The approximate cost of such a furnace is about \$100.

400 fire-brick	\$20.00
400 red brick,	5.00
200 lbs. fire-clay,	8.00
Mason, five days, \$5 per day,	25.00
Castings,	20.00
Extras, mortar and carpenter,	10.00
	<hr/>
	\$88.00

For transportation, etc., will require about \$10.

Such a furnace is hardly suitable for a mine unless it is well equipped in its various departments, and has a large amount of fire assaying to do.

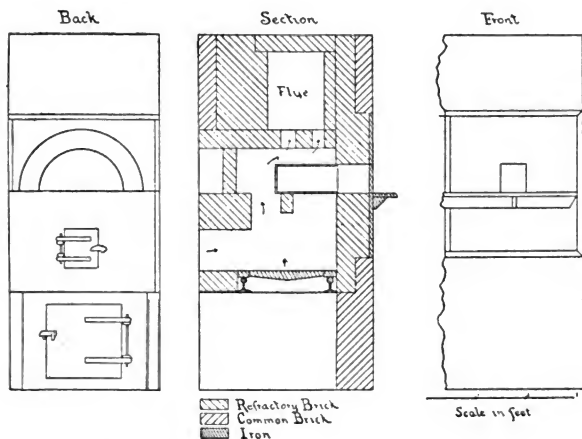
The superiority of this style of furnace over every other consists in:

Its economy of fuel (I have made cupellations on 16 lbs. of soft coal); its cleanliness, being far less filthy than the Kerl Furnace which is fed in front.

Its rapid heating and excellent draughts.

Its large muffles.

I have worked with the Kerl Furnace, the double muffle and the Battersea, and I consider this the best.



A furnace which is fed behind is always to be preferred to one fed in front, since the heat and dust of the latter is not recompensed by any gain in time; if indeed there be any gain in time. If the grate be properly cleaned or barred out with a long iron bar, and sufficient coal put in, the quantity being easily determined by practice, it need not be touched again during the assay. The increase of temperature required at the end of an assay for brightening a bead, removing the last traces of lead, or perfect liquidation

in scorification, can be got by stirring the coal a little and closing the furnace door. The draught is excellent, and the position of the flues, as will be seen, causes the flame to circulate entirely around the muffle. There is one disadvantage, and that is the danger in feeding of breaking the cross-bar, *i.e.*, the supporting fire-brick under the muffle; this may be remedied, however, by constructing knees or projections from the wall which serve as a rest. With care a muffle in constant use should last a month, and then a new bottom may be inserted from an old muffle. When the muffle finally becomes unfit for use the bricks in the arch are carefully shoved in without damaging them, so that they may be used again, and the new muffle thrust into position. The arch is again walled up with fire-brick and fire-clay mortar. A little fire-clay mortar at the front where the muffle touches the door, is often necessary. The furnace should now be allowed to stand a short time till the mortar is nearly dry. The muffle should be placed with a slight slope from the back to the door. This admits of a freer circulation of air, and enables the operator to see into his cupels.

Another slight objection which I found in working with this furnace was the distance of the muffle door from the floor. It will be seen by the diagram that it is four feet. For my own use and for others of medium height, six inches less would make it more convenient.

The size of the muffles used is:

Small size, 9 inches by 15 inches.

Large size, 13 inches by 15 inches.

I have made thirty cupellations at once in the large size and got crystals on all. Twenty crucible assays may be made without difficulty at one time.

The most refractory ores may be made easily by crucible process. About thirty to forty minutes is required for a crucible assay in this furnace. I worked some eight months with this furnace, and met with no such satisfaction in any other that I ever used.

MANUFACTURE OF SLAG BRICKS IN MONTANA.

By THOMAS EGLESTON, PH.D.

THE utilization of the slags of the various kinds of furnaces, which not only produce nothing but are a source of great inconvenience and expense to the proprietors of works, has been the subject of much experimentation. As the quantity of slag produced in most of the works using shaft furnaces is equal in weight and greater in bulk than the amount of profitable material treated, a large amount of money has been spent in making experiments with a view of utilizing them.* These consist of in some way causing the slag to cool slowly, so that it becomes less brittle than when allowed to cool by itself, and thus becomes useful in construction; or else in causing the slag to run against a rapid stream of water, so as to granulate it, in order to use it for the manufacture of manure, sand or cement, or to carry it away as a waste product.

The cooling process, when it is carried to its greatest limit, produces a material equal to cut stone, but it requires time and a large amount of space.† In many cases thorough tempering, as the cooling process is called, is not necessary, and in the great West especially, is not always practicable, and when the slag is not too basic the process of tempering can be carried on economically by doing it only partially. The slags of the West are not usually decomposed by the atmosphere and have great resistance to crushing, but are very brittle. When they do not require much handling, they can be used, when moulded, with great advantage for the construction of retaining walls, foundations, and of kilns for roasting ore or matte, while the chips are useful for making roads and the fines for casting beds, for which last purpose they are cleaner than sand, and require no addition of fluxes when the castings are treated in the furnace, since the slag is fusible. In order to make them cheap, it is desirable to have the shaping done in cast-iron moulds which can be easily taken apart and quickly put together again. Casting in sand, with sheet-iron partitions, as is

* *Transactions American Institute Mining Engineers*, vol. i., page 206.

† "Treatment of Copper-Slates at Mansfeldt," *SCHOOL OF MINES QUARTERLY*, vol. xii., p. 113.

done at Mansfeldt, is only desirable when there is a large space and considerable force employed, when labor is cheap and there

SLAG BRICK MOULD
PULVER HINTS
BUTTE, MONTANA.

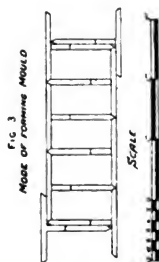
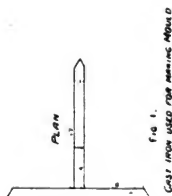
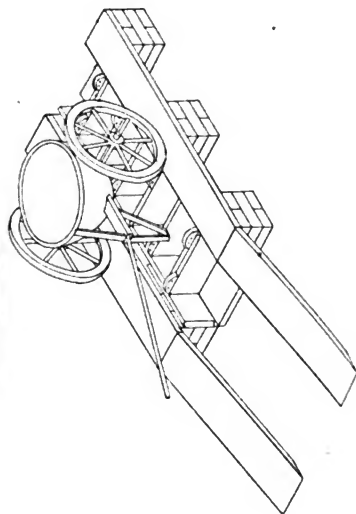


FIG. 4.
SKETCH SHOWING MOULDS IN USE



ELEVATION



FIG. 2.
CAST IRON ETC PLATE



is a constant demand for the product, for only in this way can the

skill be acquired which is necessary to get a material which is always uniform.

The process which is used at the Parrott Works at Butte, Montana, was invented by Mr. J. E. Gaylord, of that company, and is interesting because it allows of quickly arriving at the result with ordinary labor, and is applicable anywhere and to almost any slag, provided it holds together on cooling, as almost all the slags in the West do. It consists simply in dumping the fluid slag from the inside of the ordinary conical iron pot into a cast-iron mould, instead of allowing it to get cool in the pot and then throwing it on to the dump heap. This requires that the casting yard shall be near the furnaces, so that the slag pots shall not have to be wheeled too far, and that the space shall be large enough for the men to work conveniently, and also space for the storage of the hot moulded slag while cooling. The plant required for this manufacture is of the simplest description, and the product available for almost any building required about the works, or, indeed, for any ordinary construction, especially for underground work.

The slag-bricks at these works are made by contract, and are paid for at the rate of 85 cents to \$1 per hundred. The bricks are 12 inches long and six inches wide and high. This has been found by experience to be the most convenient size, but they might be made of any other size when it was desirable to do so. The Parrott brick weighs about 55 pounds; one man can make 350 in a day. They are made on an area near the blast furnaces. At these works there are two plants for making them, each plant having three sets of apparatus at a distance of about 30 feet apart. These three sets are worked by one man in the day and one in the night shift; or four men in 24 hours. When there is a greater demand, extra sets can be easily set up or shifts of eight hours can be made. The apparatus consists of a set of cast-iron plates, shown in the plan and elevation No. 1. These plates are cast in the shape of a T and have beveled ends. They are one inch thick, 14 inches long, 12 inches wide on the inside and 14 on the outside. The bevel occupies one inch, so that the available inside space is twelve inches long and six inches wide and high. This piece is set upon a series of bed-plates, Fig. 2, which are fourteen by six and one and one-half inches thick. These are leveled up and form a floor, and are juxtaposed so as to leave their joints under the mould frames. The frames are placed together, so as to form five moulds, so that

the pointed, beveled ends of the long end of the **T** fit into the **V**-openings made by placing the beveled ends of the short ones together. The method of placing them is shown in Fig. 3. No special end pieces are made for the purpose of resisting the pressure, but two of the castings are placed at the end for that purpose. On the outside of these and resting upon supports, nine inches high, plates of cast-iron six inches wide and of the same thickness are set, a little longer than the length of the five moulds. They are reached by an incline three feet long, placed as shown in Fig. 4, so that the wheels of the slag-pot will run on them and be just over the moulds below. The incline is so gentle that there is no difficulty in pushing the slag-pot up it. The pot full of slag from the furnaces is run up this incline. The man shoving it makes two holes in the crust, which has cooled on the top, while coming from the furnace, the front one to pour the slag out and the one on the other side behind it to allow of the flow. He then tips the pot over by raising the handle of the slag-wagon and the melted slag on the inside falls into the moulds below until they are full. There will then be a shell of slag on the inside of the pot. This is carried to the dump heaps and tipped there, and the pot is taken back to the furnace to be again filled. By the time the moulds in plant No. 3 are full, the brick man, who has just prepared these moulds and has watched the operation of casting, is ready to take to pieces the bed No. 2 previously cast. He goes there, and with a hook which fits into the holes on the top of the castings, shown in the elevation, Fig. 1, pulls out the irons and puts them to one side, leaving the hot bricks on the iron pavement to cool sufficiently to be handled. When this is done he goes to No. 1, the bricks of which have been cooling and are ready to be piled, but are still hot. He takes them up on a shovel and piles them close together, making headers every other row. He then reconstructs the moulds in No. 1, putting the irons, which are still hot, in place by means of the hook, washes them with clay water, and by this time the bricks of No. 2 are ready to be piled. He first goes to No. 3, pulls out the irons and then piles the bricks of No. 2, and by this time fresh slag comes to No. 1, and so on. It does not take much more than ten minutes between the casting of one set and the making of the piles of the other. The bricks are left in the pile until they are quite cool, by which time they are sufficiently annealed to be used.

There is always a considerable quantity of small stuff made by

the slopping of the slag. This is taken away by one man with a horse and cart, and is used for making the roads about the works and for filling either between masonry or in the ground. These bricks are constantly used about the works, and considerable quantities of them are sold to be used in the town. They are very advantageous for construction, as they require less mortar than ordinary bricks, and are quite as strong as stone, when they are not liable to shock. They are used exclusively in the construction of the kilns at that works, where they would last a very long time, but for the habit of cooling down the hot ore with water, which makes it necessary to reconstruct them every four or five years. The bricks of the size made here are the most convenient. If made smaller they would cost too much, since the labor would be about the same whatever the size. If made larger they would be too heavy for the men to handle conveniently. They can be transported short distances and are cheaper and more easily laid up than stone.

The skill of the manufacture is entirely in keeping the irons above ground, moving them frequently and keeping them coated with clay water. When, as in some cases, the moulds have been permanently fixed in place and the slag allowed to cool in them, the cast-iron pieces have become useless in a short time. At the Parrott Works, where the work is done carefully, they last indefinitely, and where the moulds are taken to pieces as soon as the bricks are strong enough to hold themselves up, the wear is inappreciable. The process is a very ingenious and simple one and applicable at any works producing slag. The cost of the plant is very small, the labor required is not high-priced, and over two-thirds of the slag is a source of a small profit to the works, instead of being an incumbrance and a source of expense.

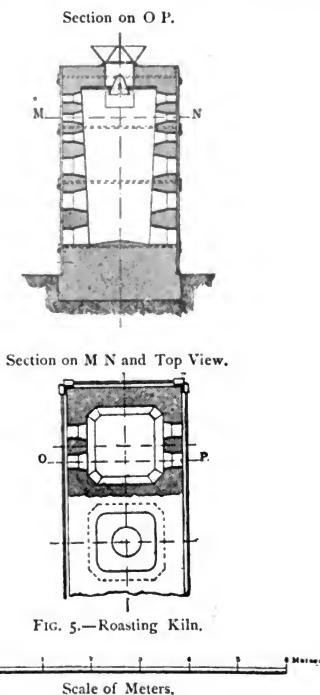
THE TREATMENT OF COPPER SLATES AT MANSFELDT.

By T. EGLESTON, PH.D.

(Continued from p. 117.)

3. *Roasting the Matte and Making Sulphuric Acid.*—The matte from all the works is collected at Eckardt Hütte and Kupferkammer Hütte to be roasted, the object of which is both to drive off the sulphur, which is not required in the following operations, and to

oxidize the iron, so that it may combine with silica and pass into the slag. This roasting is done in kilns, Fig. 5, which are small shaft-furnaces, 3.20 m. high. At the hearth, they have a section of 1.35 m. by 1.36 m., and from here they widen gradually to the throat, where they have a section of 1.60 m. by 1.56 m. These kilns contain, when full, ten tons of matte. Two sections of them



are shown. They are built in groups of twelve to eighteen, side by side, in two rows, and connect with the sulphuric acid chambers. Each kiln is charged by a cup and cone. The top of the cup is covered by a movable cone as shown in Fig. 6. The charging-cone is arranged so that it can be raised or lowered above or below

a circular hopper set permanently in the kiln. Above the throat there is an ore-hopper, and fitting over it and moving either with, or independently of, the lower cone, is an upper one, which fits over the ore-hopper and is brought down on to it when the ore is to be charged, so as to prevent the sulphuric acid from escaping from the throat when the lower cone descends into the furnace. The top of the furnace thus remains covered. If there is any obstruction in the upper part of the kiln, it can be broken up by working with iron bars through a hole made in the upper cone, while the under one is lowered. When the charge is made, the lower cone is first raised to its place, the top one is then lifted and a new charge put into the hopper. In the interval before charging, the joints between the cup and the cone are covered with fine ore. Between the charges, the upper cone remains raised.

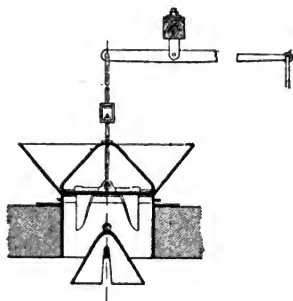


FIG. 6.—Details of the Cup and Cone Charger.

Scale—0.03 m. = 1 m.

The kilns were first constructed as shown in the Fig. 5, with four small doors in two rows at the top and three larger ones in a single row below, but since the introduction of the double cone, the four small upper doors have been suppressed, as the upper part of the furnace can now be reached without inconvenience to the men, through the cup and cone from above, and they are no longer of use. In the lowest door only, there is an opening for the admission of air, which can be open or closed more or less, at will. In the new furnaces, the four upper doors are no longer put in. In the old ones, they are tightly luted and never used.

When the furnaces are cold they are charged with matte broken to the size of 0.30 CbM to 0.40 CbM, and mixed with small coke. After the matte has taken fire, no fuel is added, as the sulphur in the matte is sufficient to furnish all the heat required. The only care the men have to exercise is to see that the charge does not sinter. This is done by making the charge of 100 of raw and 85 of either half roasted or wholly roasted matte, and by opening one of the three large doors to allow the air to enter and thus keep down the heat. The quantity of air is so regulated as to give a gas containing 4 to 5 per cent. of sulphurous acid. The men know that the kiln is working properly when the upper part of the charge, about one metre above the hearth, which is not thoroughly roasted, will hold itself up when the fully roasted charge below is withdrawn. When the finished charge has been drawn out, the pasty mass above is broken up with bars, so that the whole mass falls without much disturbance to the working. The gas from each furnace escapes by an opening in the top of the shaft into a canal common to all the kilns, and goes from there to the acid chambers. The kiln is discharged every twelve hours in the ordinary working, but for the "bottom process" every eighteen hours. A fresh charge is introduced immediately after a finished one is withdrawn. In the interval all the doors of the furnace are closed and luted. They are not opened except when the furnace is not working properly. With the poor ores treated at Kupferkammer Hütte, 0.615 tons of roasted matte is withdrawn at each discharge, or with the rich ores at Eckardt Hütte, 0.75 tons. The roasted matte comes out of the furnace in rounded pieces of a dark color, more or less agglomerated, but which can be easily separated. It contains about ten per cent. of sulphur. The outside of the pieces looks more or less scoriaceous. The inside is a kernel which looks like the concentrated matte. As the amount of sulphur driven off is a little more than equalled by the oxygen absorbed, one ton of matte at Kupferkammer Hütte gives 1.070 tons of roasted matte and at Eckardt Hütte 1.015. The daily production of each kiln is, at Eckardt 1.37 tons and at Kupferkammer Hütte 0.97 tons. At Kupferkammer Hütte there are 72 of these kilns, 48 in two rows of 24 rows each and one row of 24. At Eckardt Hütte there are 44, or 116 kilns in the two works. The roasting is well done and costs but little.

Sulphuric acid is manufactured on a large scale at both Kupfer-

kammer Hütte and Eckardt Hütte. This is done in lead chambers, the acid manufactured being from 48° to 53° B. The table below gives the apparatus required at each of these works for this purpose :

	Kupferkammer Hütte.	Eckardt Hütte.	Total.
Kilns,	72	44	116
Lead Chambers,	5	3	8
Volume of lead chambers in C. M.,	21423.66	13008.52	34432.18
Gay-Lussac towers,	5	3	8
Glover towers,	3	2	5

From 550 cubic metres of lead chamber one ton of chamber acid at 50° B. is produced in 24 hours. The chambers are 5 m. high, 5.5 wide and of variable length, depending on the lay of the ground and the work to be done. At Eckardt Hütte there are three, one 67 m., one 60 m., and one 5 m. They manufacture the nitric acid which they use. Saltpetre is used for that purpose only. The section of the Gay-Lussac and Glover towers which they formerly used were oblong. The new ones are round and answer equally well. These towers are built with slag blocks made for the purpose. The concentration of the chamber acid is done in platinum vessels. The chamber acid contains a small quantity of selenium and a trace of arsenic. It would not be worth while to take out the arsenic, but the selenium has to be separated, as much of the acid made in the works is used in dyeing and the selenium turns the substances which are dyed red. To separate it and the arsenic, all the acid which has to be concentrated up to 66° B. is treated with sulphuretted hydrogen, made by treating iron sulphide with 18° to 20° B. acid. No use has as yet been found for the arsenic and selenium so collected, but it is all saved. Much of the acid made at Eckardt Hütte is sold for the manufacture of dynamite, for which a very regular quality is necessary. The concentration up to 66° B. is made in a Faure-Kessler platinum apparatus, which produces $4\frac{1}{2}$ to $5\frac{1}{2}$ tons of 66° B. acid in 24 hours. All the older forms of platinum apparatus have been abandoned. The 50° to 60° B. acid is sold in small quantities in carboys containing 64 to 110 kilos respectively. The most of it, however, is sent away on the railroad cars in iron cylinders, containing 10 to 12 tons. The use of lead cylinders containing $6\frac{1}{2}$ to 6.75 tons has been abandoned. To fill the iron cylinders, the acid is forced by the pressure of air through leaden pipes 750 m.

long into collecting tanks at the railroad station at Hettstedt, which is about half a mile, and the tank cars filled from there. The dirty acid which comes through the towers is clarified by causing it to pass through a number of quartz filters, from which it runs into the concentration pans quite clear. To concentrate the chamber acid into 60° B., Glover's towers are used at Eckardt Hütte and the vacuum apparatus at Kupferkammer Hütte. From 100 tons of matte there were produced at Eckardt Hütte in 1888 41½ per cent. of sulphuric acid at 50° B., and at Kupferkammer Hütte 47.6 per cent.

In the first three months of 1881 there were produced per ton of raw matte :

	Kupferkammer Hütte.	Eckardt Hütte.
Of chamber acid at 50° B.,	479 K.	413 K.
The quantity of nitric acid at 36 was,	7.92	7.50

In 1888 there were produced :

	Matte Roasted in tons,	Roasted Matte in tons,	Chamber Acid in tons,
Kupferkammer Hütte,	20878.267	21787.5	9933
Eckardt Hütte,	16113.2	11711	6688
	<hr/> 36991.467	<hr/> 38498.5	<hr/> 16621

The production per ton of raw matte was :

	Kupferkammer,	Eckardt,
Chamber acid at 50° B.,	476 K.	415 K.
Roasted matte,	1.040	1.04

The daily production of a kiln was :

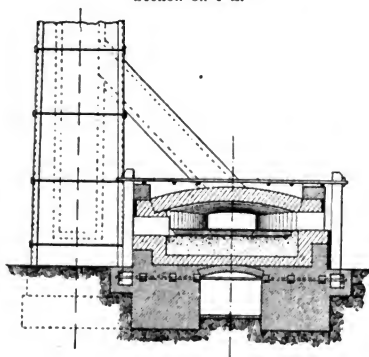
	Kupferkammer Hütte.	Eckardt Hütte.
Roasting for ordinary concentrated matte,	0.98	1.47
Roasting for the bottom process,	0.80	1.12

In the year 1889, 37,543 tons of the first and 432 tons of the concentrated matte were roasted. The raw matte produced 16,553 tons of chamber acid at 50° B.; 1529 tons of this was concentrated to 1203 tons at 60° B., and 4929 were concentrated to 3179 tons at 66°.

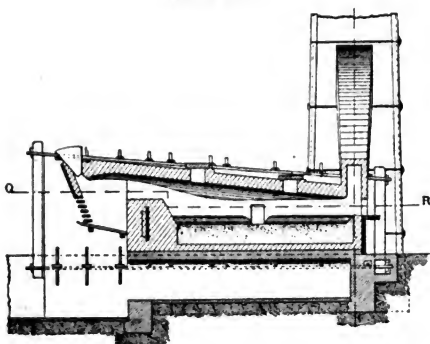
4. *Concentration of the Raw Matte.*—This work is done at Kupferkammer Hütte, where there are two works, and at Eckardt Hütte, where there is one. In the first works, the furnaces are divided into two separate establishments at different levels, in one of which there are four, and in the other, six furnaces. At Eck-

ardt Hütte there are eight, making eighteen in all. These furnaces are shown at Fig. 7. They were formerly used with step-grates, as shown in the drawing, but this has been abandoned, as it was found that the coal on the inclined grates was apt to burn in such a way as to form passages in the fuel and thus admit too much air to the furnace. The bars of the grate are now made only slightly inclined towards the bridge. The charge in the furnace is introduced by means of an iron hopper. In one section of Kupferkammer Hütte, the top of these hoppers is on a level with the

Section on Y Z.



Section on U V.



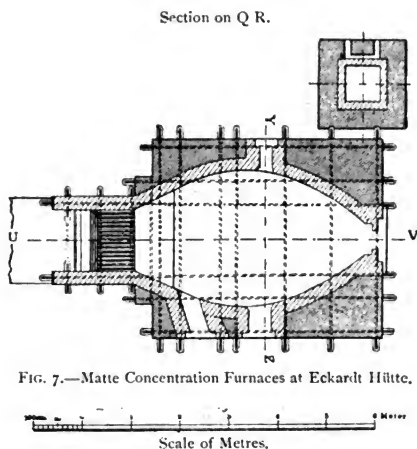


FIG. 7.—Matte Concentration Furnaces at Eckardt Hütte.

floor of the shaft-furnace houses, and they are reached by means of an iron bridge. The dimensions of the furnace are given below :

	M.
The length of the hearth is	3.00 to 3.96
The width of the hearth at the fire-bridge,	2.00
The width of the hearth at the middle,	2.74
Width at the working door, . . . . .	.54
Height at the fire-bridge, . . . . .	.82
Height at the working door, . . . . .	.41
Width of the fire-bridge, . . . . .	.76
Height from fire-bridge to roof, . . . . .	.47
Depth of grate-bars below the bridge, . . . . .	.79
Size of the flue where it enters the arch, . . . . .	.29 and .44
Length of the flue where it enters the arch, . . . . .	.63
Width of the flue where it enters the chimney, . . . . .	.45
The length of the flue is, . . . . .	.45

The fireplace is 1.05 m. long and 1.25 m. wide. The depth of coal, including clinker, is 0.70 m. at the bridge and 0.97 m. at the back. The coal is charged by a hopper. Over all the fire-bridges there is a row of openings 0.03 m. to admit air to the furnace to burn the gases. The hearth of the furnace is 0.20 m. to 0.22 m. thick. It is made of quartz sand, which is either natural or is

ground for the purpose. It is put in in three layers when the furnace is at a red heat. It is inclined away from both bridges and towards the tap-hole. The furnaces, as now built, are served at Eckardt Hütte by chimneys 14.5 m. high and 0.71 m. square. At Kupferkammer Hütte, the chimneys are 16 m. high. There are also, in the old works, two chimneys 37.7 m. high, with a section of 1.72 m. by 1 m. The furnaces last from four to five months with continuous working. At the end of that time the hearth must be made over and the arch must undergo serious repairs. The whole roof has to be rebuilt every twelve months. The fire-place has to be repaired every few weeks. The bricks which are used in the construction of these furnaces are made not far from Eisleben.

The object of the operation is to produce a matte containing from 74 per cent. to 75 per cent. of copper, which will contain all the silver, to get rid of a part of the zinc, arsenic and antimony by volatilization, and to make most of the iron and a part of the other impurities pass into the slag. As there is not sufficient silica in the roasted matte to form the slag into which the iron must go, it is added in the shape of sand. Zinc is especially prejudicial in the matte concentration, and while only a small quantity of it passes into the matte, it makes the slags pasty and causes a scum to form, which lengthens the operation and renders it much more difficult, as they do not easily separate from the matte. This is especially noticeable at Eckardt Hütte, where the ores contain but little zinc and the separation of the matte and slag takes place easily, while at Kupferkammer Hütte, where they contain a great deal, almost all the slags contain grains of matte, and have to be either re-treated or, in order to make the separation, the mattes are made to flow into conical pots, where the separation can take place. But this entails another evil, which is that the slow cooling of the rich matte involves the separation of the silver as metallic silver, which can be clearly seen with a magnifying glass and causes a considerable loss, as metallic silver is not attacked in the Ziervogels process. The operation is conducted in two ways. The ordinary concentration, which has been carried out since 1887, consists in making (a) a matte containing 74 per cent. to 75 per cent. of copper. The other (b) consists in making a matte containing 78.50 per cent. to 79.8 per cent. of copper and bottoms. Both of these mattes are sent to Gottesbelohnungs Hütte for desilverization, but the bottoms are

sent to the electrolytic works at Ober Hütte. There are used in the furnace in a shift :

	Kupferkammer Hütte.	Eckardt Hütte.	Bottom work.
	Tons.	Tons.	Tons.
Roasted matte, . . .	2.80	2.20-2.80	2-2.50
Quartz sand, . . .	0.080-0.0140	0.060-0.100	0.080-0.100

To the roasted matte at Eckardt Hütte, 6 per cent. to 7 per cent. of unroasted matte, and at Kupferkammer Hütte, 0.1 per cent. is added, and, in addition to this, the rich slags from the same treatment. The time required is six to seven hours. It is indispensable to form a thin slag, so that the separation may take place perfectly. For this purpose, as soon as the charge is introduced and spread out in the furnace, all the doors are closed and luted and the furnace brought to a high temperature as quickly as possible and kept there. After three to three and a half hours, the doors are opened and the charge rabbled. This is repeated twice and the charge is considered as ready when it is thin and nothing is found adhering to the hearth. The charge in the furnace is now composed of three beds, metallic copper below, matte above and slag on the top. The furnace is tapped and the copper is caught in small cast-iron pots. The matte is run out on to a casting-bed covered with cast-iron plates, which is 6 m. to 7 m. square, and makes plates which are 0.04 m. to 0.05 m. thick. This is done because it has been found that when the matte is in such thin sheets it cools so rapidly that no separation of the metallic silver takes place, and as this would be prejudicial to the subsequent separation of the silver, this method of casting is now adopted.

Formerly, the matte and the slag were discharged together, the matte running into the first cast-iron pot and the slag overflowing from there. In this way the grains of matte were separated from the grains of slag as now, but the matte remaining a much longer time in the melted condition, a liquation took place in the matte with a separation of the silver, which complicated the next operation unnecessarily. Since the matte has been cast in thin sheets this difficulty no longer occurs.

As soon as the slag shows itself, the spout, which is movable, is turned over the first of a series of six to eight conical iron pots, 0.60 m. in diameter and high, which hold 300 to 400 kilos each. These are arranged in cascade, so that the overflow from one runs

into the one below. This is done in order to catch the grains of matte which are carried off with the slag. The most of these separate in the first two pots. The knobs which settle in these pots are put back into the furnace. At Eckardt Hütte, just before the slag solidifies, an iron cone with a ring in it is pushed down into the melted slag in order to lift it out of the pot. To do this, a horizontal crane composed of two T-bars fastened into the side wall of the building and supported from the roof, is carried over the line of pots. A chain pulley with a hook serves to raise the solidified slag from the pot and carry it out of the building.

The slags which are produced in this process contain on the average two per cent. of copper. They were formerly all treated in the ore-furnaces, but this practice is now to be abandoned and they are to be treated in a shaft-furnace by themselves. The furnaces are tapped every six hours and yield 8 to 10 tons of white metal in 24 hours. The slags can only be cascaded when they are thin. When, as at Kupferkammer Hütte, they contain considerable zinc, they are pasty and only 37 per cent. of them will run. The rest have to be drawn from the furnace with the rabble and are always rich in grains of matte.

It is not always possible to arrange the charge so as to produce the rich matte. What can be done can usually be told from an inspection of the roasted matte. It is in reality the only way to correct it. If a mistake has been made it usually becomes apparent after the drawing of the first slag. If the slag, when it is rabbled, foams, and if the matte, when it is cooled on the rabble is too rich or contains metallic copper, the matte has been roasted too much, and an addition to the sulphur must be made by charging sufficient raw matte to furnish it. If the contrary is true and the matte has not been sufficiently roasted, rich concentrated matte or even metallic copper must be added to it to take up the sulphur. If the changes made in the charge do not succeed in bringing the matte up to the required standard, it is used in other charges. It is generally not wise to try to correct the charge towards the end of the operation, either with dead roasted or raw matte, for this introduction of cold material cools the charge and prolongs the time of roasting. When the matte cast contains considerable quantities of metallic copper, it is certain that the hearth has taken up some of it, and several successive charges of imperfectly roasted matte can then be made with a certainty of

always getting a rich matte which will not contain less than 74 per cent. With a little practice the rich concentrated matte can be accurately distinguished by the eye by its dull gray color and its fine grain. When the eye is not practiced, the only way to tell is by the specific gravity. When it contains 74 per cent., of copper, it has a gravity of 5.76, and when it contains 75 per cent. of 5.80. When bottoms are made the corrections cannot be made in the charge. Extra matte is only sufficiently rich and pure when in the shift, at least 100 kilos of bottom copper has been taken out. When this separation has not taken place the extra matte is not used as such. The concentration slag contains oxide of copper as silicate, and according as it is taken from the casting pot or flows by itself, contains more or less shot matte. On account of its basic condition and of its high oxide of iron contents it was formerly used in the first melting.

The following analyses show the composition of the concentrated matte :

	Kupferkammer Hütte,		Eckardt Hütte,	
	1880.	1881.	1880.	1881.
Iron,	1.981	2.59	1.348	2.87
Manganese, . . . . .	.....	.011	.....	.01
Nickel,	0.634	.536	0.678	.304
Cobalt,	0.212	.178	0.220	.187
Zinc,	0.995	1.378	0.674	.514
Lead,	0.835	.816	0.952	.557
Copper,	74.3	73.20	75.8	74.512
Silver,	0.365	0.427	0.358	.429
	<u>79.322</u>	<u>79.256</u>	<u>80.030</u>	<u>79.383</u>

In 1888 they contained :

	Copper.	Silver.
Eckardt Hütte,	75.9	0.436
Kupferkammer Hütte,	74.3	0.443

The bottoms contained :

	Copper.	Silver.
Eckardt Hütte,	97.03	0.907
Kupferkammer Hütte,	96.50	0.962

This matte generally contains from 20 to 21 per cent. of sulphur :

The slag contains, no alkalies having been determined :

TREATMENT OF COPPER AT MANSFELDT. 205

	Kupferkammer Hütte.	Eckardt Hütte.
Silica,	20.193	17.155
Lime,	4.730	3.946
Magnesia,	0.915	1.054
Alumina,	3.500	2.280
Oxide of iron,	50.328	48.717
Oxide of manganese,	4.110	3.481
Oxide of cobalt and nickel,	0.200	0.360
Oxide of zinc,	2.006	2.666
Oxide of lead, . . . . .	.218	0.300
Copper,	9.90	14.800
Silver,	0.028	0.050
Sulphur,	1.556	2.838
	<hr/> 98.687	<hr/> 97.647

On account of the high percentage of iron it contains, this slag is used as a flux in smelting the ore.

The table below gives the working for 1880 :

	Kupferkammer Hütte.	Eckardt Hütte.
Tons of matte treated daily,	8.01	9.34

Per ton of raw matte :

	Kupferkammer Hütte.	Eckardt Hütte.
Concentrated matte,	410	540
Concentrated slag,	570	500
Coal used,	9.88	8.58

One ton of the concentrated matte contained :

	Kupferkammer Hütte.	Eckardt Hütte.
Copper,	743.91	743.75
Silver,	4.27	4.33

One ton of concentrated slag contained :

	Kupferkammer Hütte.	Eckardt Hütte.
Copper,	90.40	29.43
Silver,	0.36 .10	0.85
The coal used per 1 ton of raw matte,	5.88	8.58

In 1888 the work was as follows :

	Ordinary Concentrated Matte.		Bottom Work.	
	Kupferkammer Hütte.	Eckardt Hütte.	Kupferkammer Hütte.	Eckardt Hütte.
Daily product from a furnace of roasted matte.	8.97	10.49	7.79	8.81
Coal used per ton of roasted matte, . .	10.75	8.57	11.35	9.98

Results per ton of matte :

	Ordinary Concentrated Matte.		Bottom Work.	
	Kupferkammer Hütte.	Eckardt Hütte.	Kupferkammer Hütte.	Eckardt Hütte.
Concentrated matte, . .	4.80	5.60	.....	.....
Extra matte, . . .	.....	.....	3.29	3.55
Bottom copper, . . .	.....	.....	54.07	.76
Slag,	5.49	4.98	6.39	5.31

On an average one ton of ordinary concentrated matte contains :

	Ordinary Concentrated Matte.	
	Kupferkammer Hütte.	Eckardt Hütte.
Copper,	742.	751.39
Silver,	4.38	4.417

One ton of extra matte :

	Bottom Work.	
	Kupferkammer Hütte.	Eckardt Hütte.
Copper,	786.	796.415
Silver,	4.199	4.121

One ton of bottom copper :

	Bottom Work.	
	Kupferkammer Hütte.	Eckardt Hütte.
Copper,	965.	973.072
Silver,	9.622	9.094
Lead,	11.06	7.7

One ton of flowing slag :

	Ordinary Concentrated Matte.		Bottom Work.	
	Kupferkammer Hütte.	Eckardt Hütte.	Kupferkammer Hütte.	Eckardt Hütte.
Copper,	34.017	29.980	81.067	78.740
Silver, . . . . .	.054	.046	0.269	0.110

One ton of drawn slag :

	Ordinary	Concentrated Matte, Kupferkammer Hütte.
Copper,		95.253
Silver,		0.385

The copper in these slags is partly as silicate and partly as mechanically mixed shots. The ordinary concentration slag goes back to the first melting. The rich slags of the bottom work are collected for a separate campaign in the shaft furnace.

In 1889, 41,376.8 tons of roasted raw matte gave 21,039.5 tons of concentrated matte and 315 tons of bottoms. The matte averaged 75 per cent. to 75.7 per cent. of copper and from 0.44 per cent. up to 0.0466 per cent. of silver. The bottoms yielded 95.3 per cent. to 96.88 per cent. of copper and 0.947 per cent. to 0.961 per cent. of silver. The total cost of the first fusion, roasting and second fusion for that year was 5,123,458.71 marks.

5 and 6. *Desilvering the Concentrated Matte.*—The separation of the silver was formerly done from black copper. A series of experiments made during the years 1869 and 1871 proved conclusively that better copper could be made when rich mattes were desilverized than when the same operation was carried out on black copper. Up to that time the mattes were made to contain 64 per cent. to 65 per cent. of copper, and these were made into black copper and desilverized. Since 1874 the mattes have been made to contain 74 per cent. to 76 per cent. of copper. These are desilverized and the residues sent to the copper refining works. The desilverization is done by the Ziervogel's method, which is carried out at the Gottesbelohnungs Hütte, and the electrolytic method, which is practiced at Ober Hütte. To desilverize the matte by the Ziervogel method it must be crushed to a fine powder. To do this it is first broken up by hand with hammers then ground. It was formerly granulated and stamped and afterwards ground in stone mills. These mills have been entirely replaced by ball mills, of which there are five. The matte from Eckardt Hütte is ground at Katharinen Hütte by a mill driven by water-power, and that from Kupferkammer Hütte is ground at Gottesbelohnungs Hütte by four mills run by steam. With these mills the work is much better done and dust is avoided. The daily output of a ball mill is from fifteen to twenty tons of ground matte. The product of the mills

in 1888 was 19,363 tons. The ground matte is delivered to the works in quantities of fifty tons at a time. This is carefully sampled and its copper and silver contents determined in the laboratory at Eisleben. The roasting of the matte is done in furnaces with four-hearths, of which there are ten. These furnaces are very cheap to build. The desulphurization furnaces yield ten tons a day and the silver sulphate furnaces seven tons. The ten furnaces treat 19–2000 tons of ground matte a year. The process is a delicate one and involves the transformation of the iron and copper into sulphates, and of then conducting the operation so as to form silver sulphates and of decomposing the iron and copper sulphates towards the last, so that when the powder is treated with hot water the silver sulphate alone will be soluble as sulphate, while the other materials will be insoluble oxides. The hot solution of silver sulphate is run over metallic copper, which precipitates it, while the copper goes into solution. The copper is precipitated as cement copper and goes to the refining works. The residues from this treatment, which still contain over 0.023 per cent. of silver, are roasted and treated a second time for silver, after which they contain on the average not more than 0.017 per cent. of silver. These and those which contain less than 0.023 per cent. are sent to the copper refining works. The cement silver, after having been carefully washed, is pressed, dried and melted in graphite crucibles and cast into bars. In the year 1889, 20,921 tons of ground and roasted matte produced 87,127.5 kilos of cement silver, which made 86,850.5 kilos of pure silver 999 fine, which is equal to 86,714.48 kilos of fine silver. The yield of a ton of concentrated matte was 4.131 kilos of fine silver. This corresponds to a yield of 89 per cent. to 94 per cent. of silver. The cost of desilverization was 684,285.15 marks.

7. Making refined copper out of the desilverized copper residues.

The residues from the desilverization works consist of copper oxide, which contains only a small per cent. of iron, nickel lead and zinc oxide. Previous to 1880 this was smelted for black copper and either refined in a low hearth or in a reverberatory furnace. Since that time the manufacture of black copper has been abandoned. The residues are now refined at once in the reverberatory furnace, three sections of which are shown in Fig. 8. As the process is now conducted, the desilverization works deliver their residues to the copper refining furnaces, which are situated at Gottesbelohnungs Hütte and Siege Hütte, where there are nine furnaces, five to six of which

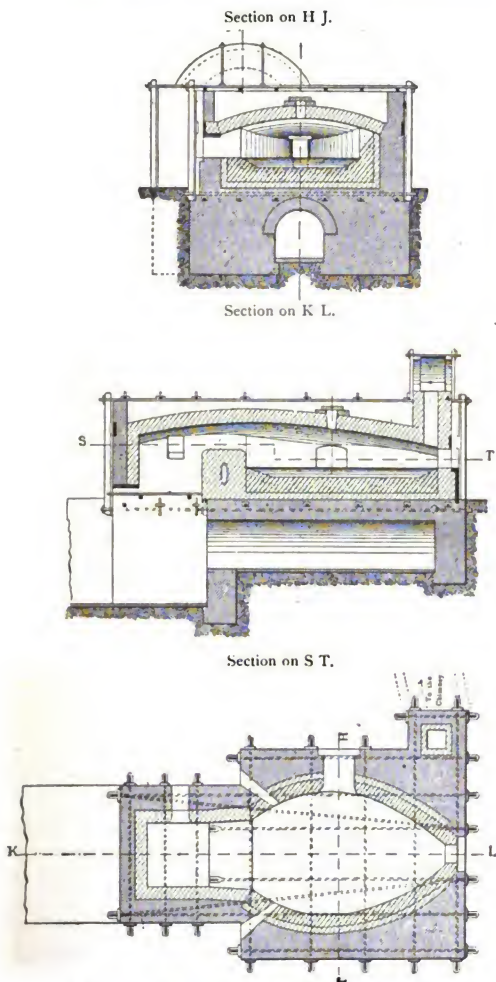


FIG. 8.—Copper refining furnace at Gottesbelohnungs Hütte.



are always in work. These connect with a chimney 31.385 m. high. The residues from the desilverization of ordinary mattes contain 74.5 per cent. of copper. Those from the extra mattes contain 79.5 per cent. They are delivered wet and must be allowed to drain for some time. They are weighed out in charges of ten to twelve tons and placed on a drying floor made of iron plates which cover the underground flues of the furnace, which serve also as dust chambers. They remain here for eighteen hours. They are then mixed with 8.65 to 9 per cent. of fine coal and charged in the hoppers of the refining furnace. The charge generally consists of about ten tons. After a previous charge has been withdrawn for an hour and the furnace is at a dull red heat, eight tons are introduced and spread out over the hearth. The last two tons are not introduced until five hours later. The treatment lasts twenty-four hours, and consists of several phases, which are the charging, the melting, the rabbling, fining, refining and casting.

(a) The melting period lasts nine to ten hours, during which time all the doors of the furnace are closed and luted and the temperature raised as high as possible. During this time the coal, which has been mixed with the charge, reduces the copper oxide, and if the charge has been properly made the oxides, other than copper not being reduced, pass by virtue of their combination with the silica of the hearth and the silica and alumina of the coal ashes into the slag, carrying with them only a small amount of copper. The bath is rabbled, and when everything is melted, the slags are removed. An assay of the normal working now taken shows a peculiar fracture. The lower half is compact, of a copper-red color; the upper half is cracked and of a dirty-red color. The upper surface is uneven and bubbly and irregularly sunken against the thin edges which first cool. If too much coal has been mixed with the charge, the fracture appears gray, as much of the foreign metal oxides have been reduced. The upper surface is generally convex and more or less scaly from the sulphurous acid given off and the lower part against the side of the spoon full of holes.

(b) The removal of the slags takes about an hour. It must be done at a high temperature, but they are easily separated from the matte and do not remain attached to the tools. These slags are rich and form the refining slags (a). In order to separate the sulphur of the matte, it must be oxidized from five to six hours

longer. In the commencement of this operation white vapors are given off in abundance and are so thick as to obscure the view of the interior of the furnace. This smoke is composed partly of sulphurous acid but mostly of zinc oxide. The bath is cleaned quickly from the scorias in order that the air may strike its surface. To make the oxidation most effective, the doors and the air-openings are kept open, if the temperature of the furnace will allow it. The metals are oxidized, first iron, then zinc, which is partly volatilized and then oxidized and a considerable part of it carried off as vapor; the lead, and, lastly, the nickel are oxidized. All of these pass wholly or in part into the slag. The copper being the heaviest, sinks to the bottom. The lighter materials rise and form small quantities of slag, which are collected with a wooden pole. Sticks of wood are thrown into the furnace to assist in the separation of the metal from the slags, which are tough. This oxidation and removal of slags and separation of the smoke lasts one and a half to two hours. Towards the last the smoke decreases and the scums diminish in quantity. The scorias which form at this time are thin, and when cold show a red, shining surface. They must be constantly shoved to one side with a wooden pole until they have accumulated in sufficient quantities to be removed from the furnace.

(c) The sulphur is not yet entirely out of the copper and the oxidation has to be continued for about two hours more to remove it. During this time the sub-oxide of copper which forms decomposes the remaining copper sulphide. The oxidation is recognized to be complete when the upper surface of the rising copper on the assay sample is unequal in different parts of the assay and is in places broken through, from which the melted copper flows out in little streams, looking, when cold, like worms. The upper surface of the assay is a very dark red and has a great deal of lustre. The lower surface is, however, dull and free from blow-holes. The copper now contains several per cent. of sub-oxide of copper and a very little sulphur.

(d) The bath is now ready for poling. To effect this a pole of wood seven to eight metres long is placed in the furnace with its butt end towards the fire-bridge and supported on the outside of the door, tight against its upper side by a crutch of wood. The hydrogen, carbides of hydrogen and carbonic oxide produced by its burning cause the bath to boil and produce a separation of the sul-

phurous acid and the reduction of the sub-oxide of copper. Very soon after the commencement of the boiling, the assays taken no longer rise, the color is without lustre, dark red, and the assay is slightly sunken in the middle, and, when broken, shows a bluish-red fracture with a cubical crystalline structure, in which there are only a very few small bubble-holes. The crystalline structure is a sure sign that the oxidation has been carried far enough. If it does not show itself it will be rarely true that the sulphur is all gone, and the oxidation will have to be repeated until it is. When the poling is continued, the cubical fracture disappears entirely and it becomes granular. The copper oxide makes the red color of the assay dark on the surface, while in the lower part there are spots which are lighter. In the following assays, the red becomes brick red on the fracture of the assay and the structure is more or less fibrous. The upper part, which, until this time, has been dull, becomes somewhat stringy in the middle of the button and a more or less large hollow space appears. After this, the assay looks stringy and fibrous and a separation takes place in about one-quarter of the height of the assay, from which the threads and fibres run with regularity towards the sides. In casting, the upper surface sinks and in its middle a dark point appears. When the assay is broken, a hollow space is shown under this point. When the poling is continued this disappears. The fracture on the underside becomes finely fibrous, but granular on the upper. Immediately under the upper surface, a strip 0.001 m. to 0.002 m. wide appears, which has a shining, metallic lustre, in which with the magnifying glass fine bubbles, due to the escape of the last traces of sulphurous acid may be seen. The whole upper surface has the same appearance, but it cannot be seen by the eye. When the copper is wholly fined, the upper surface of the assay is bright and covered with little rosettes, which can only be seen with a magnifying glass. The upper surface is slightly concave. The fracture appears fine-grained, the color is a uniform brick-red and begins to have a visible metallic lustre. This period lasts from two to two and a half hours. In the meantime, on account of the doors being constantly open during this time, the temperature of the bath has fallen considerably, which helps the separation of the sulphurous acid.

(*c*) At this time, all the openings into the furnace are carefully closed. The surface of the metal is covered over with hard-wood

charcoal to prevent further oxidation, and the heat raised during one-half to three-quarters of an hour. When the bath has attained the proper temperature, the refining commences, which has for its object the complete reduction of the copper oxide. This is accomplished by poling repeatedly from fifteen to twenty minutes at a time. The assay shows at the commencement the same brick-red color, but with little lustre, and is hard and brittle on account of the sub-oxide of copper contained. The poling has now only the chemical effect to reduce the sub-oxide by means of the carbonic oxide and the carbides of hydrogen produced by the burning of the wood. During this period the assays must be constantly taken, as the reduction takes place very rapidly. The original dark color decreases with every assay, while the metallic lustre increases. The process is finished when the whole surface of the fracture is silky and shows the red of metallic copper and is fine-grained throughout, while the upper surface on cooling does not sink, which it always does when sub-oxide is present.

(f) When the assay shows these characteristics, which can only be detected accurately after long practice, the poling must stop, otherwise the copper would be in danger of becoming over-poled. If it is continued, although there is no sub-oxide present, shining white strips appear, first on the fracture and then on the surface of the assay, which increase in width little by little and form hollow places with a yellow lustre and render the copper impure. The period of poling lasts three-quarters of an hour.

When the metal is impure and contains arsenic or bismuth, it becomes red-short. It was formerly the opinion that over-poled copper was caused by the formation of copper carbide, as carbon was frequently found in small quantities in such copper. According to the researches of Dr. Hampe, of Clausthal, it appears that the phenomena of over-poling are caused by an absorption of the carbonic-oxide produced by the burning of the wood and absorbed by the metal. These researches show that in this condition, arsenic and bismuth make the copper red short, for both these metals may be present in the metal with sub-oxide of copper dissolved in it and as such do no harm in small quantities, but they became harmful when they are reduced by over-poling. When the metal becomes over-poled, it will have to be fined and refined again.

(g) After the copper has been thoroughly refined, it must be cast, which takes from two to two and a half hours, and during this time the metal often goes back, that is, takes up oxygen, so that frequent assays must be made to ascertain if this is so, and in that case to repeat the poling as often as may be necessary.

The amount of refined copper of the best quality produced from the ordinary desilverized residues is 67.7 per cent. to 68 per cent. and about 16 per cent. of scorias, which are sent to Siege Hütte to be treated. From the rich matte it is from 71.5 per cent. to 72 per cent. with 10 per cent. of residues. Of the first, there were produced in 1888, 11017 tons, and of the last, 1631 tons. Both kinds are cast into bars and stamped with the mark M R A, and are used for making brass and belong to the finest grades made in commerce. When copper for rolling is to be made, about $7\frac{1}{2}$ kilos of lead, evenly spread over the surface, is added to the charge. This makes the copper very soft for rolling, but all of the lead can never be removed, and it injures the quality of the copper for any other purpose. The following series of analyses is interesting as showing the progress made at Mansfeldt in the purity of its products. These analyses are arranged chronologically, commencing when the works made black copper.

Refined copper made from black copper :

	1860.	1864.	1864.	1864.
Iron,	0.065	0.068	0.070	0.054
Nickel,	0.311	0.468	0.455	0.345
Lead,	0.780	0.316	0.574	0.593
Copper,	98.358	99.120	98.401	98.375
Silver,	0.028	0.028	0.020	0.022
Oxygen, . . . . .	.....	.....	0.640	0.591
Sulphur,	0.043	.....	0.009	0.025

Refined copper from black copper :

	1864.	1864.	1868.
Iron,	0.069	0.059	0.044
Nickel,	0.409	0.327	0.437
Lead,	0.169	0.120	0.132
Copper,	99.277	99.274	.....
Silver,	0.024	0.025	0.031
Oxygen,	0.096	.....	.....

Refined copper made from the desilverized products :

	Rosette Copper. 1860.	Black Copper.	Ordinary Residues.				Extra Con- centrated matte, 1888.
			1872.	1887.	1888.		
Iron, .	0.065	0.059	0.065	0.070	0.025	0.016	.....
Nickel, .	0.311	0.327	0.343	0.262	0.268	0.240	0.121
Lead, .	0.780	0.120	0.043	0.108	0.071	0.049	0.030
Copper, 98.358	99.274	99.50	99.485	99.491	99.587	99.745	
Silver, .	0.028	0.025	0.026	0.028	0.024	0.025	0.028
Sulphur, 0.043	.....	.....	.....	.....	.....	.....	.....

The following are the analyses of the cast copper for brass rolling during 1879-80 :

1879.						1880.					
	Iron.	Nickel.	Lead.	Copper.	Silver.	Iron.	Nickel.	Lead.	Copper.	Silver.	
Jan.		0.271	.....	99.496	0.028	0.025	0.259	0.056	99.536	0.029	
Feb.		0.299	.....	.....	0.030	0.044	0.241	0.043	99.509	0.030	
March.		0.274	.....	.....	0.030	.....	0.219	0.103	99.460	0.030	
April.		0.306	.....	99.503	0.028	.....	0.233	0.103	99.520	0.030	
May ...		0.306	.....	99.533	0.029	.....	0.231	0.043	99.550	0.029	
June		0.295	.....	99.500	0.030	.....	0.240	0.049	99.530	0.029	
July.		0.290	.....	99.560	0.032	0.132	0.247	0.061	99.402	0.029	
August.		0.294	.....	99.500	0.026	0.131	0.253	0.017	99.524	0.030	
Sept.		0.266	.....	99.576	0.032	0.042	0.275	0.055	99.394	0.028	
Oct.		0.281	.....	99.520	0.030	0.032	0.263	0.071	99.447	0.030	
Nov. ...	0.037	0.297	0.042	99.512	0.028	0.059	0.239	0.053	99.446	0.030	
Dec.		0.249	.....	99.508	0.027	0.034	0.268	0.077	99.414	0.028	

The scorias (a) which come from the refined copper are taken to Siege Hütte below Hettstedt and by a reducing action in the shaft furnaces, with the addition of 15 per cent. of lime as a flux, made into black copper with 92 per cent. of copper, and this is made in a blown furnace into blister copper, with 98 per cent. copper, and from this with the addition of some lead and phosphide of copper, made into a ductile copper for rolling, which is used for rods, bars, and all kinds of sheet copper, and is known as B copper, and sent to be rolled and hammered at Rothenburg and Eterswalde.

The composition of the copper for rolling was, in 1880:

	Iron.	Nickel.	Arsenic.	Lead.	Copper.	Silver.
March,		0.366	0.144	0.259	99.110	0.016
April,		0.358	0.115	0.259	99.184	0.016
May,		0.314	0.119	0.134	99.270	0.016
June,		0.389	0.081	0.235	99.190	0.020
July,	0.019	0.314	0.133	0.155	94.129	0.018
September,		0.378	0.105	0.137	99.167	0.018
October,	0.024	0.394	0.116	0.206	99.192	0.020
December,		0.405	0.101	0.235	99.124	0.018

Other analyses are given below: 1 and 2 are of the mark M R A for brass, which is the best copper made; 3 to 6 are for rolling. 3 was made out of the desilverized residues at Gottesbelohnung Hütte, 4 was made at Sieger Hütte from slag, 5 and 6 copper for rolling made out of slags.*

	Cast Copper.				Sheet Copper.	
	1.	2.	3.	4.	5.	6.
Iron,	0.024	0.037	trace.	trace.	0.024	0.019
Nickel and cobalt,	0.317	0.279	0.298	0.467	0.394	0.314
Arsenic,	0.025	.....	0.030	0.061	0.116	0.131
Lead,	0.016	0.042	0.204	0.206	0.206	0.155
Copper,	99.442	99.512	99.340	99.198	99.192	99.129
Silver,	0.026	0.028	0.023	0.014	0.020	0.018

They are expecting to manufacture from the extra concentrated matte residues and from the raw matte from Koch Hütte made from the specially pure ores, a copper containing 99.8 per cent. of copper.

8. *Treatment of the Scorias.*†—The refining slags (*a*) are smelted at Siege Hütte in a shaft-furnace, which is 6 m. high and has two tuyeres on opposite sides. It has an interior hearth which is made of quartz bricks, and is tapped every hour. The slags *a* are smelted with 15 per cent. of lime and 10 per cent. to 15 per cent. of masses taken from the fining and refining furnaces, and 600 K. of fluxes. The coke required is 16 per cent. to 17 per cent. of the charge. The furnace is blown with cold blast. The acid bricks of the hearth are eaten away in three to four days and require repair. At the end of three weeks they must be renewed. When the slags produced contain more than $1\frac{3}{4}$ per cent. of copper, they are treated with the necessary fluxes in the same fur-

* Berg und Hüttenmännische Zeitung, 1887, p. 482.

† Berg und Hüttenmännische Zeitung, 1887, p. 489.

nace, and when they are poorer they are thrown away. The copper (*b*) made from these scorias contains :

Iron,	0.267	0.423
Cobalt,	0.193	3.448
Nickel,	3.137	
Arsenic,	1.107	0.128
Lead,	2.733	3.558
Copper,	92.100	91.854
Silver,	0.012	0.013
	<hr/>	<hr/>
	98.549	99.424

This is treated in 10-ton charges in a large blown reverberatory furnace for thirty hours, when it is poled. The blister copper (*c*) produced contains 97½ per cent. of copper and .015 per cent. of silver. It is cast in sand moulds and produces refining scoria (*d*) rich in nickel. The copper is treated with lead, 7½ kilos being added to a charge of nine tons, and copper for rolling is made, which is called B refined, and is made into sheets at Rothenburg and Etterwalde. The composition of this copper is shown in the analyses Nos. 5 and 6 p. 55, refining slags are produced with it (*e*). Every year from 11,000 to 12,000 tons of this copper is made, which, on the average, contained in 1888 :

Nickel,	0.427
Lead,	0.163
Copper,	99.213
Silver,	0.013

The fining slags (*d*) are melted with lime and furnace hearths in a shaft-furnace and produce an impure copper (*f*), with 65 per cent. to 66 per cent. of copper. This is treated for blister copper (*g*), with 97.5 per cent. of copper, and added in small quantities when the blister copper (*c*) is refined. The very rich nickel alloys (*h*), with 33.8 per cent. to 35.5 per cent. of copper and 29.008 per cent. to 32.2 per cent. of nickel and cobalt, are stamped and sent to the cobalt blue works. Of this, in 1888, 65.6 tons were produced. The slags from the slag smelting are treated in a shaft-furnace with pyrites and matte. The refining slags (*e*) are smelted by themselves in a shaft-furnace, and produce impure copper (*i*), which is treated for blister copper, which is refined. The slags (*j*) are melted with pyrites for a raw matte rich in nickel. The slags from the shaft-furnaces which were produced by smelting

the substances rich in nickel, which contained 2 per cent. of copper and 5 per cent. to 7 per cent. of nickel, are smelted with the addition of 20 per cent. to 25 per cent. of pyrites until they contain less than $1\frac{1}{2}$ per cent. of copper, and a copper made which contains 12 per cent. to 13 per cent. of copper and 16 per cent. to 18 per cent. of nickel, which is sold. The resulting rich matte contains :

Copper.	Nickel and Cobalt.
13.75	18.17
12.55	15.66
14.10	19.24

About 90 tons of this material are produced every year.

Very small quantities of arsenic, antimony and bismuth make the copper unfit for many uses. 0.1 per cent. of arsenic or antimony makes it red-short and unfit for brass or wire. Bismuth is, if anything, worse. 0.05 per cent. makes it strongly red-short and perceptibly cold-short beside. They do not often occur, but when they do, the copper must be treated until they disappear.

The total production of copper in 1889 was 15,330 tons, which cost 454,138.39 marks. The sales amounted to 15,925.25 tons, the largest quantity ever sold in any one year. 84,821.97 kilos of silver were also sold in the same year.

The production of copper, in tons, for three years is given below :

	1887.	1888.	1889.
Sheets of all kinds,	12,927.8	11,083.26	12,096.30
Boilers,	857.2	837.51	685.82
Boiler bottoms,	714.6	425.82	660.84
Round and square bars,	732.6	1355.65	1890.04

A BRIEF REVIEW OF THE LITERATURE ON ORE-DEPOSITS.

By J. F. KEMP.

(Continued from Vol. XI., p. 359.)

V.

GEOLOGICAL surveys, under the auspices of the national government, were early instituted in the United States in connection with the various exploring expeditions into the western country.

Except in the case of Foster and Whitney's survey of the Lake Superior region (1850-51) such work in the East, until within the last decade, was done entirely by the several States. We have as the result a few volumes descriptive of the geology along the routes traversed by the different parties, but these cover only small and isolated portions of the whole area. After the close of the war, surveys were organized on a more extended scale. In 1867, the Geological Exploring Expedition of the 40th Parallel was authorized by Congress under the direction of the War Department. Clarence King was appointed director, and his reports were made to the chief of the United States engineers. In the same year the Geological and Geographical Survey of the Territories was instituted and placed under the control of the Department of the Interior. F. V. Hayden was put in charge, and his reports were addressed to the Secretary of the Interior. Likewise, in 1867, the United States Geographical and Geological Survey of the Rocky Mountain Region was authorized and placed under the direction of the Department of the Interior. Major J. W. Powell was put at its head, and the reports were made to the Secretary of the Interior. In 1869, the United States Geographical Surveys west of the 100th meridian were organized by Act of Congress and placed under the War Department. Lieutenant G. M. Wheeler was appointed director. The reports were addressed to the chief of the United States engineers.*

The fact that these surveys often covered the same territory, and the conflicts, jealousies and lack of efficiency brought about by their being under different departments drew the attention of the National Academy, and through its influence, in 1879, the United States Geological Survey was established, consolidating the whole governmental work of a geological character under one responsible head, attached to the Department of the Interior and closely connected with the National Museum. Clarence King was the first director, but after one year's service he resigned, and was succeeded by Major J. W. Powell, the present incumbent. Under

* In this connection, see 43d Congress, 1st Session, Exec. Doc., No. 240, p. 6.; 1st Ann. Rep. Dir. U. S. Geol. Surv. (Clarence King), 1880, p. 4.; Powell's Testimony Before the Joint Commission, 49th Congress, 1st Session, Senate Misc'l Doc., No. 82; Presidential Address of J. C. Branner before Section E. of A. A. A. S., 1890, printed in *Amer. Geol.*, Nov., 1890. Powell's testimony gives a concise account of geological surveys in all countries, p. 418.

Major Powell's able administration the survey has accomplished some very grand results, and to its work the literature of ore-deposits owes some of its most valuable monographs.

The results of the 40th Parallel Survey were embodied in seven final reports and an atlas. Of these, volume iii., on Mining Industry, is of especial interest, but many observations of local significance are recorded in volume ii., which is entitled Descriptive Geology. Volume i., on Systematic Geology, by Clarence King, discusses the broader structural relations for which volume ii., by Arnold Hague and S. F. Emmons furnishes many of the details. The report on Mining Industry opens with a general discussion by Clarence King, of the distribution of the western mining districts and shows that, to a certain extent, they occur in zones on the great lines of structural disturbance.* A chapter on the Comstock Lode follows, also by Clarence King. This is discussed later, p. 221. The engineering and metallurgical features of the operations on the lode are subsequently treated by J. D. Hague, and the chemistry of the Washoe process by Arnold Hague. Central Nevada next receives attention, and the technical operations are again described by J. D. Hague, while the geological portion is treated by S. F. Emmons and Arnold Hague. From the pen of the former comes the paper on the geology of the Toyabe Range, which embraces the Reese River mining region, with its high grade silver-ores in narrow veins, mostly in granite. Arnold Hague describes the geology of the White Pine District, with its rich silver-ores in Devonian limestone. Mr. Emmons adds a short account of the gold quartz-veins of Egan Cañon. Passing over the chapter on the Green River coal-basin, by Clarence King, we find a general account of the mining resources of Colorado (1869) by J. D. Hague, and then by the same writer, an excellent description of the gold deposits of Gilpin county† and the silver deposits

* This theme was first elaborated by W. P. Blake in the Report of the California State Board of Agriculture, 1866. It has also been discussed by R. W. Raymond, Geographical Distribution of the Mining Districts in the United States, *Trans. Inst. Min. Eng.*, i., 33; by G. F. Becker, in vol. xiii., Tenth Census, p. 5, and A. J., S. iii., vol. 28, 1884, p. 209; and S. F. Emmons, The Structural Relations of the Ore-Deposits, *Trans. Inst. Min. Eng.*, 16, 804.

† These deposits have likewise been described by S. F. Emmons, Tenth Census, vol. xiii., p. 68; F. M. Endlich, Hayden's Survey, 1873, p. 280; A. N. Rogers, *Trans. Inst. Min. Eng.*, vol. ii., p. 289; A. Lakes, Annual Report Colorado State School of Mines, 1887, p. cii.

of Clear Creek county.* The reports pass over the mines of the Bingham and Cottonwood cañons, south of Salt Lake City, and the omission is to be regretted, as good detailed descriptions of these districts are much needed. Their general geology is somewhat discussed in volume ii., p. 443.

The volume on Mining Industry was one of the very first reports on the western regions of unbiassed character and written in a really scientific spirit. It deserves the highest praise and to its credit it may be said that it now is a quite rare book and difficult to obtain.

The publications of the U. S. Geological and Geographical Survey (Hayden's) consist of twelve annual reports, bulletins, miscellaneous contributions and a series of monographs. Of these, the annual reports contain essentially the material of economic interest and this only in scattered places. That of 1869 (combined reports, 1867, 1868, 1869), p. 201, has a chapter by Persifor Frazer, Jr., on the Mines and Minerals of Colorado, which, while especially concerned with Gilpin and Clear Creek counties, has also notes on a trip south along the eastern slope into New Mexico. The report for 1870 is confined to Wyoming, and its economic part deals especially with coal. The report for 1871 describes southern Montana and has but few references interesting in this connection. The same is true of the volume for 1872, which deals with portions of Montana, Idaho, Wyoming and Utah. For the next few years, operations were mostly confined to Colorado. The report for 1873, p. 275, contains a report by Dr. F. M. Endlich, on the mining districts of Colorado, which, after a brief general introduction, takes up Gilpin and Clear Creek counties and gives some very excellent cross-sections of the veins. The same region is again referred to in the report for 1876, p. 117. In the report for 1874, Dr. Endlich briefly describes the veins of the San Juan region, then but little developed. The subsequent volumes, while filled with valuable geological material, contain almost nothing demanding further mention here. On June 30, 1879, the survey ceased to exist by law.

* Reference may also be made to S. F. Emmons, Tenth Census, vol. xiii., p. 70; to the *Eng. and Min. Jour.*, Feb. 1, 1879, p. 73, and Feb. 19, 1878, p. 108; F. M. Endlich, Hayden's Survey, 1873, p. 293; R. Pearce, *Proc. Colo. Sci. Soc.*, iii., p. 71; J. J. Stevenson, Wheeler's Survey, vol. iii., p. 351; F. L. Vinton, *Eng. and Min. Jour.*, Sept. 13, 1879.

Powell's survey was mostly confined in its operations to the plateau region along the border of Colorado and Utah, and the reports and monographs contain little concerning ore-deposits. The survey of the Black Hills was, however, also undertaken and placed in the charge of Henry Newton and W. P. Jenney. The economic portion is from Jenney, and was first issued in 1876 as a separate report of 71 pages and a map. The entire report came out in 1880, after the lamented death of Newton. Mr. Jenney's chapter on the mineral resources deals especially with the auriferous gravels, and as the region was but then thrown open to prospectors, is largely of the character of a scientific reconnaissance which, indeed, was greatly needed.

Wheeler's Survey issued eight quarto volumes with one supplement, a series of annual reports of progress and certain special or miscellaneous reports. Of these, volume iii. of the quarto series and its supplement, as well as several of the annual reports, merit passing attention. Volume iii. and supplement give a general account of the geology of Nevada, Utah, Arizona and Colorado, by Messrs. Gilbert, Marvine, Howell and Stevenson. In Howell's report, p. 257, there is a description of the Raymond and Ely vein at Pioche, Nev., and of the others near it, with several geological sections. This is followed by a brief account of the great magnetite deposits of southwestern Utah with analyses. In the supplementary volume there is to be found (pp. 389-406) a brief summary of the economic resources of southern Colorado and northern New Mexico. Volume i. of the quarto reports has lately appeared (1889). Although it is often stated in the annual reports that this would contain a full account of the mines of the region covered, for some reason such mention is of the briefest nature.

The annual reports are to be found as appendices to the annual reports of the chief of engineers. That of 1869 contains scattered references to mines in southeastern Nevada, and the one for 1871 has many notes on eastern Nevada and northern Arizona, especially by G. K. Gilbert. The report for 1872 mentions the mines in western Utah and eastern Nevada. The reports for 1873, 1874 and 1875 contain nothing of interest in this connection, except, perhaps, the mineralogical report in the last-named (App. G 2, p. 97) on northern New Mexico and southern Colorado. Appendix H 2 of the report for 1876 has a mineralogical and geological description of northeastern California, with some unimportant notes

on the veins of California, and an analysis of the Temescal tin-ore. In Appendix H 4, A. R. Conkling has a brief account of the Spanish Peaks and the Culebra, Cimarron and Taos ranges in Colorado and New Mexico. In 1877, J. A. Church was placed on the Comstock, and in the volume for this year and the next makes a preliminary report. His completed work was afterward separately printed and is noted under the general review of the Comstock literature later. The reports for 1878 and 1879 have a series of further notes on the mining districts of California.

As stated above, about 1879-80, all the four surveys were merged into the present United States Geological Survey. No small portion of the resources of the latter has been devoted to the detailed study of mining districts, and the monographs now to be reviewed have resulted.

The great amount of gold and silver produced by the Comstock Lode has made it one of the most famous of mining districts. The vast extent of the excavations, the remarkable heat phenomena, and the interesting eruptive rocks, which form its walls have all drawn scientific attention upon it to an unusual degree. The early report of von Richthofen (now professor in the University of Leipzig) was made in 1865 for the Sutro Tunnel Company, and was privately printed in San Francisco. Although the explorations then were only a fraction of what was accomplished later, von Richthofen seems to have outlined the geological structure with great skill. He showed that the ore-body filled a fissure on the contact between a so-called syenite and an eruptive rock that he called propylite. The ore and gangue were thought to have been brought up from below by solfataric action, in which fluorine, chlorine and sulphur were the principal dissolving agents. He gives a general comparison of the Comstock with other noted silver mines the world over, and from these considerations seeks to draw inferences about the portions not then reached. Later developments and studies have largely confirmed his predictions.

The Comstock lay in the strip studied by the survey of the 40th Parallel, and received much attention from Clarence King. The results of his studies made in 1867 and 1868 are embodied in volume iii. of the final reports. Mr. King brings out forcibly the fact that the foot-wall of the vein is but the natural continuation of Mt. Davidson, and that the vein fills a fissure between the syenite of which Mt. Davidson consists, and the late Tertiary eruptive

rocks poured out against its flank. The geological succession of these and the filling of the vein from solfataric action attendant on a thin dike of andesite, which found its way into the old contact fissure, are successively traced.

The survey west of the 100th meridian under Capt. Wheeler, also found the Comstock in their field, and J. A. Church, about ten years after Clarence King's visit, studied the vein and reported on it. Meantime, the determinations of the rock species had been changing from time to time, as will be briefly summarized later, and the rock of Mt. Davidson, called above syenite, was found to be diorite by Zirkel. Mr. Church* imagines this to have poured out originally in thin horizontal sheets, which were folded in east and west folds. This was to account for the bendings of the lode as now seen. On the diorite was poured out next the propylite, likewise in successive horizontal sheets. Then they were all tilted along a north and south axis and eruptions of andesite penetrated between their beds in very large amount. Further movements forced the convexities of the first-formed folds against the andesite and crowded their substance sidewise to some extent into the synclinals. This movement slightly parted the sheets, affording water-courses through which rose silicious waters. These dissolved away the neighboring sheets, leaving extensive quartz bodies in their places. They also removed the andesitic caps. No ore was formed as yet. Now followed great trachyte eruptions on the east and loaded down the hanging-wall of the lode so heavily as to cause a downward movement of it on the foot, making a new series of openings, and into these poured the ore-bearing solutions which brought the precious metals. No one who intelligently follows this explanation will doubt that Mr. Church is a very ingenious man and yet few would be inclined to have much confidence in this long unnatural hypothesis when a simpler course will lead to the same results.

At the time of Mr. Church's visit, the workings were becoming very deep, and the great heat was manifesting itself, which has been since such an obstacle. Flooded drifts, it was thought, had been noticed to grow hotter, and from this the remarkable hypothesis of kaolinization was conceived. It was that the kaolinization of the feldspar in the deeply-buried rock occasioned

* The Comstock Lode, its Formation and History, Wiley, 1879.

the heat of the lode. With the reorganization of the geological surveys, in 1879, one of the first steps was to place Mr. G. F. Becker on the Comstock to make a further study. Explorations had meantime opened up much new ground, both horizontally and in depth, and the opportunities were better than ever. Mr. Becker pushed his studies under Mr. King's brief administration and completed them after Major Powell had assumed the directorship. They were published in 1882, as Monograph III. of the U. S. Geological Survey.* Mr. Becker first describes very briefly the general economic and geological relations of the district and then summarizes the work of his predecessors.† This is followed by a discussion and determination of the rocks of the district. A few changes are introduced in the classifications of previous writers, and the extended alteration of the rocks described and commented upon, as it figures largely in the hypothesis later advocated for the origin of the ore. Chapter IV. traces the results of faulting, and it is shown that under conditions like those prevailing, the surface would tend to assume an outline approximating a logarithmic curve. The surprisingly close coincidence of the profile with such a curve is remarkable. It is shown by figure in Plate XLVII. of the abstract in the Second Annual Report. Mr. Becker next takes up the rocks in their time succession and discusses the chemical nature of the changes in them. After describing the lode itself, the origin of its metalliferous contents is traced as follows. Waters under hydrostatic pressure from the heights to the west are supposed to have percolated towards the lode passing through deeply-buried regions of heat. They were probably diverted from rising directly through the lode by an impervious clay seam and were thus forced to soak through the diabase hanging, relieving it in passage of the metals which were afterwards deposited in the higher portions of the lode. The metals themselves were probably largely derived from the augite of the rock. Mr. Becker had associated with himself, for the sake of studying the heat phenomena (and especially the hypothesis of kaolinization) and the electrical manifestations of the lode, Dr. Carl Barus. The results of Dr. Barus' careful experiments throw

* A concise abstract appears in the Second Annual Report of the Director U. S. Geological Survey, 1880-1881.

† In the preceding review, this summary has been of great assistance, as its condensation of the other authorities could scarcely be improved upon.

great doubt on kaolinization as a source of heat.* The electrical experiments were not very satisfactory and were carried on also at Eureka, Nev. No very definite results were reached.† In Chap. X., an interesting summary of what had been done by previous electrical investigations is given. A general summary of the monograph concludes the volume. An atlas of beautifully printed maps and sections accompanies the report. The volume is a fine piece of careful work and reflects the greatest credit on the author and the survey.

The correct determination of the eruptive rocks neighboring to the Comstock has been of great importance, not alone because of their scientific interest, but as bearing on the fact as to whether the lode itself was a contact-fissure between two different rocks, or whether it was a simple fissure-vein. It is worthy of note, that in connection with it, von Richthofen developed one of the first important attempts to classify the volcanic rocks, and that Hague and Iddings have finally urged that the peculiar crystalline structures of all eruptive rocks depend primarily on the heat and pressure (*i.e.*, depth below the surface) under which they have solidified, destroying thus the time-element in classification. Von Richthofen, in the report for the Sutro Tunnel Company, and in his later memoir on "The Natural System of the Volcanic Rocks,"‡ distinguished in the Washoe district syenite, metamorphic rocks, quartz-porphyry, propylite, sanidine-trachyte, and very subordinate andesite. Mr. King referred much of the propylite of von Richthofen to andesite, but retains the propylite as a distinct species, although remarking the close affinities of the two. He calls the quartz-porphyry, quartz-propylite. In other respects no changes are introduced. Zirkel§ determined the syenite as granular diorite, and while accepting hornblende-propylite and quartz-propylite as separate species, called the greater part of the quartzose rock dacite. He introduces for the first time augite-andesite, rhyolite and basalt. Mr. Church paid less attention to lithology, and uses the terms of his predecessors somewhat loosely. Mr. Becker makes the following classification: Granular diorite porphyritic diorite, micaceous diorite-porphyry, quartz-porphyry,

* See also the *QUARTERLY*, vol. vi., Nov. 1884, p. 1.

† See also *Proc. Inst. Min. Eng.*, vol. xiii., p. 417.

‡ *Cal. Acad. of Sci.*, 1867. Also *Zeitschrift d. d. Geol. Gesell.*, 1868, 663.

§ 40th Parallel Survey, vol. vi.

earlier diabase, later diabase, earlier hornblende-andesite, augite-andesite, later hornblende-andesite, and basalt. In this it will be seen that several new varieties are introduced, but the main mass of Mt. Davidson was still considered diorite, and the vein was thought to lie between this and some of the other species mentioned, especially diabase. In 1885, Arnold Hague and J. P. Idings completed new microscopical studies upon the materials collected by Mr. Becker, and the results were published as Bulletin 17, of the U. S. G. S.* These two writers had had more to do with the eruptive rocks of the Great Basin and Pacific Slope than any other geologists, and brought to the review an exceptional experience. Nowhere else in the world are such exposures and thorough sections afforded, alike in depth and horizontal extent. They proved that the diabase and augite-andesite shaded into each other, the differences in crystallization being due to depth. That the hornblende of the so-called diorite was largely secondary from original augite, being derived by paramorphic change (uralitization), and that the diorite was but a structural variety of the diabase. That the porphyritic diorites shade into the earlier hornblende-andesites, and are structural varieties of them. That the mica-diorites and later hornblende-andesite were identical in the same way. That the assumed Pre-Tertiary age of the quartz porphyry was unwarranted, and that it was partly dacite and partly rhyolite, the two shading into each other. That the younger diabase, so-called, of the sub-surface dike was identical with the rock elsewhere occurring on the surface and called basalt, and was really a basalt, owing its holocrystalline character to its depth. And finally the most important conclusions of all in this connection (although the other conclusions are among the most important petrographic advances made in late years) "that the Comstock lode occupies a line of faulting in rock of Tertiary age, and cannot be considered as a contact-vein between two different rock-masses."

The crystalline structure of the Washoe rocks has been subsequently treated by Mr. Becker.† The various structures, granular,

* On the Development of Crystallization in the Igneous Rocks of Washoe, Nev., with Notes on the Geology of the District.

† "The Washoe Rocks," *Bulletin Calif. Acad. Sci.*, vol. ii., p. 93, Jan. 1887, and the "Texture of Massive Rocks," *American Journal of Science*, iii., vol. xxxiii., p. 50, 1887.

porphyritic and glassy—are referred more to differences in composition and fluidity than to circumstances of solidification.

In monograph IV. of the survey, Mr. Eliot Lord has described the miners and the methods of mining employed in the lode.

In monograph VII., J. S. Curtis takes up the silver-lead deposits at Eureka, Nevada. These mines were rendered famous by the great litigation between the Eureka and Richmond companies in 1877. A large number of leading experts were brought together to testify as to the character of the deposits with very contradictory results. Mr. Curtis shows that the deposits are in a zone of limestone of Cambrian age, which has been fractured and crushed by an extensive faulting movement. Through this the ore-bearing solutions circulated and deposited the ore in the form of sulphides, probably by replacement of the limestone.* The subsequent oxidation, rearrangement and shrinking of the sulphides left frequent caves above the masses of ore. The author favors this view rather than the idea that there were pre-existing caves in which the ore was originally laid down, although he gives this explanation a full and fair statement. All the ore-bodies are connected with more or less strongly marked fissures which doubtless served as conduits for the original solutions. Mr. Curtis expresses himself as unable to classify them according to their shapes, as these are so irregular, and refers them to the category described by the German term "stock." A very careful series of assays of the country-rocks was made to determine the probable source of the ore. These seem to indicate that it came from a quartz-porphyry outcropping in the neighborhood and thought to be extensive beneath. From this the metals are thought to have been derived by the leaching action of heated waters rising from below. The memoir is an excellent piece of work and maintains the high standard set by the survey. The general geology of the district is treated in a separate monograph by Arnold Hague (yet to be issued).

Monograph XII. is devoted to the geology and mining industry of Leadville, and is from the pen of S. F. Emmons. The work was begun under King's administration and completed and published in 1886 under Powell's. A preliminary abstract appears in the Second Annual Report of the Director, 1882. The work,

* THE QUARTERLY, vol. x., pp. 122 and 329.

which consists of one large volume of 770 pages and 45 plates, and an atlas of 35 sheets, opens with a brief history of Leadville and an account of its general geography. The general geological structure of Colorado follows and a detailed description of the Mosquito Range, lying just east of Leadville itself. The mountains consist of Archæan gneisses and schists on which were deposited up to the close of the Cretaceous 10,000 to 12,000 feet of conformable sedimentary beds. About the close of the Cretaceous a great intrusion of eruptive rocks into these sedimentary strata took place, piercing them as dikes and penetrating between the beds in enormous sheets. The mineral solutions bringing the ores followed the eruptive rocks and formed the deposits chiefly along the under contact of the sheets and the upper sides of beds of blue dolomitic limestone belonging to the Lower Carboniferous.

The elevation and faulting of all followed in the general upheaval of the Rocky Mountains at the close of the Cretaceous or about the beginning of Tertiary times. The geology of Leadville itself is then described and the numerous faults carefully traced. A general discussion of the geological phenomena follows.* The petrographical description of the eruptive rocks was entrusted to Dr. Whitman Cross, and forms an appendix to this portion of the report which is Part I. Part II., on Mining Industry, opens with a general and suggestive essay on the classification of ore-deposits and then discusses those of Leadville in particular. In addition to what is mentioned above, it is brought out that the ores were doubtless deposited as sulphides, and when the containing limestone was at least 10,000 feet beneath the surface, and that they are now mostly earthy lead carbonates with cerargyrite, limonite, manganese compounds and a variety of other minerals due to their position, as now mined, being in the oxidized zone. Many interesting facts about the alteration of sulphide ores are brought out here and subsequently. The thesis regarding the origin of the ores which the writer proposes to prove, is then briefly stated as follows:

- I. That they were deposited from aqueous solution.
- II. That they were originally deposited mainly in the form of sulphides.

* In this connection, Emmons' paper, *Orographic Movements in the Rocky Mountains*, *Bull. Geol. Soc. of America*, vol i., p. 245, is of interest.

III. That the process of deposition was a metasomatic interchange with the material of the rock in which they were deposited.

IV. That the mineral solutions or ore-currents concentrated along natural water-channels, and followed by preference the bedding planes at a certain geological horizon, but that they also penetrated the adjoining rocks through cross joints and cleavage planes.

The following points are also advanced:

I. That the solutions came from above.

II. That they were derived mainly from the neighboring eruptive rocks.

The structure of the several hills, Iron, Carbonate and Fryer and the outlying mining districts, are next discussed by way of arraying facts from which to draw an argument. In Chapter VI., this is made in support of the above propositions. It is exceedingly able and deeply interesting. The general facts are incontrovertible, and the replacement origin is very generally accepted. The two additional propositions that the solutions came from above and that the metallic contents were derived from the neighboring igneous rocks, are less admitted. In regard to the latter, the numerical mistake in the table, on p. 583, which makes the metallic contents 100 times larger than they ought to be, is a serious if not fatal objection. A. A. Blow,* of Leadville, has brought forward many facts, too numerous to mention here, as the results of seven additional years of mining development, which controvert the former, and it would seem now that the ore-currents came from below, following chiefly the gray porphyry. F. T. Freeland† had previously brought out additional new facts as had C. M. Rolker.‡ Mr. L. D. Ricketts' monograph on the Ores of Leadville (Princeton, 1883), appeared long before Mr. Emmons' final report and is a very excellent piece of work. Despite the objections to individual points, Emmons' work remains as a monument of careful record and skilful treatment, and in method and results is a notable addition to the literature of the subject.

* See A. A. Blow, *Geology and Ore-Deposits of Iron Hill, Leadville, Col.*, *Trans. Inst. Min. Eng.*, June, 1889. In briefer form the paper was previously published in the *Annual Rep. of State School of Mines, Golden, Col.*, 1887.

† F. T. Freeland, *Trans. Inst. Min. Eng.*, 14, 181.

‡ C. M. Rolker, *Trans. Inst. Min. Eng.*, 14, 273 and 949.

Monograph XIII. is devoted to the quicksilver-deposits of the Pacific Slope, and comes from the pen of G. F. Becker. Alike in the general and economic geology and the petrography of California, it adds much that is new to our knowledge, and dealing as it does with one of the very few significant districts where ore-deposition is now going on (see QUARTERLY, July, 1890, p. 360) the book gives some much needed insight into the actual chemistry of the origin of ores. While not appropriate in this place to state too much of purely geological interest, it may be said that Mr. Becker indicates that granite underlies the Coast Range, and has probably afforded the material of the later sediments. These are both metamorphic and unaltered sediments. The metamorphism is developed in rocks of early Cretaceous age (Neocomian) called the Knoxville series, and probably took place at the epoch of their upheaval before the middle Cretaceous times. The metamorphic action is somewhat irregularly manifested, and has left in places unaltered portions that show the original sediments sometimes with a few fossils. The metamorphic rocks are grouped as partially metamorphosed sandstones, granular metamorphic, glaucophane schists, phthanites and serpentine. It is shown that a sandstone passes into rocks closely resembling holocrystalline eruptive rocks—two varieties of which are called pseudo-diorite and pseudo-diorite,* from their close resemblance to diorite and diorite. The phthanites are highly silicified shales. The serpentine is derived from original fragmental rocks, at times through the intermediate stage of the granular metamorphics. The importance of these changes as throwing light on the possible origin of Archæan schists, etc., which is such an active question at present, cannot be passed without comment.

Following the Knoxville comes the Wallala beds, first separated and identified by Mr. Becker. They are found in two widely separated areas, one north of San Francisco, the other in southern California, and are of Middle Cretaceous (Turonian) age. Following the Middle Cretaceous came a great depression of the Coast Range and the deposition of the Chico or Upper Cretaceous, and this deposition continued conformably with change of fauna

* J. D. Dana had previously applied the terms metadiabase (shortened form of metamorphic diabase) and metadiorite to similar rocks from Connecticut—and it would have prevented a duplication of terms to have employed them.—See *American Journal of Science*, iii., vol. xi., p. 119.

through the Tejon (Eocene) series. The Miocene is not sharply distinguished except by change in fauna, but at its close came the great Post-Miocene upheaval determined by Whitney. The subsequent sedimentary deposits are only a few Pliocene lake beds. After the Miocene immense outbreaks of andesites occurred at intervals until the close of the Pliocene, and during the Quaternary and up to modern times there have been recurrent basaltic outflows. The cinnabar-deposits are chiefly in the metamorphic rocks of the Knoxville, but they are found also in all the later sedimentaries and in the eruptive rocks likewise. They are always associated with the latter, either close at hand or somewhat remote, and probably owe to them the heated circulations which have brought the ores to their present resting places. The cinnabar is almost always directly associated with quartz, and while chalcodony and opal are in great quantity in the mines, they are not in actual contact. It occasionally is embedded in calcite. Metacinnabarite is sometimes abundant enough to be an ore. The other principal associated minerals are pyrite and marcasite. Chalcopyrite is known, as are gold, stibnite, millerite, bitumen and some rarer ones.

The cinnabar is proved in every case to fill pre-existing cavities, and these are shown to be dependent on fissures, although at times to be quite irregular. The author is led to a general discussion of mineral veins (p. 407) and suggests the terms *linked vein* (German Gangzug) for a series of associated fissures, and *chambered vein* for a vein that has at intervals, wide places and enrichments of the walls, such as are usually called stockworks or impregnations associated with a vein. For the large irregular bodies along the outcrop, the term *cap chamber* is suggested.

The chemistry of the deposition is shown to depend on the solubility of cinnabar in solutions of sodium sulphide with which it forms several sulpho-salts. Sodid hydrate, sulphhydrate and carbonate may be present without preventing the solution. Ammonia at ordinary temperatures and pressures prevents the solution, but not at 145° C. As ammonia is found at Sulphur Bank and escapes toward the surface, this reaction is cited as the cause of precipitation. (Compare Leconte, as cited in QUARTERLY, July, 1890, pp. 360-361.) Elsewhere, precipitation is chiefly referred to diminished temperature and pressure. Attempts were made with great success to imitate in the laboratory the natural operations, and too

much praise cannot be given to such endeavors to bring these processes out of the domain of speculation into that of actual experiment and demonstration.* The source of the cinnabar is thought from many suggestive facts, to be in the granite, but although analyses of fresh rock yielded antimony, arsenic, lead, copper, gold and silver, no mercury was detected. Its absence is attributed to the variability in the composition of the granite.

In general, it may be said that the monograph is a very thorough and suggestive book and is beautifully gotten up. While it is probable some of the conclusions, geological and otherwise, may not be admitted without discussion, such a course would lead to even better results. Sulphur Bank and Steamboat Springs have attracted such general attention in previous years that considerable has been already written on them. It may be regretted that in speaking of these and, indeed, of the other deposits, Mr. Becker did not give a short summary of what had been previously done, that a reader at a distance might be the better informed. Leconte's papers and those of others receive the briefest if, indeed, any mention at all.

The annual volumes of the U. S. Geological Survey on Mineral Resources, of which six have now been issued, are essentially statistical. But except in the case of the precious metals, much of great interest is to be found on ore-deposits, and the books often contain material not accessible in other quarters. They began with the volume for 1882. The first three were under the superintendence of Albert Williams, Jr.; the last three have been under David P. Day.

Two volumes of the Tenth Census contain much that is valuable in this connection. Volume xiii., which is devoted to the precious metals, affords the most thorough and reliable general sketch of the geology and mining industries of the West yet issued. The work was done by S. F. Emmons and G. F. Becker, under the direction of Clarence King. Under the two general divisions of the Pacific Coast and the Rocky Mountains, each State and Territory is taken up, and after a geological sketch its ore-deposits are described by counties.

Volume xv. is devoted, so far as geological features are concerned, to iron and coal, for while there are tables relating to the

* A summary will be found in the *Amer. Jour. Sci.*, iii., XXXIII., p. 199, 1887.

production of the other base metals, there is nothing further except some metallurgical descriptions. Iron-ore deposits are treated in great detail. The work was done under the direction of Raphael Pumpelly, by E. R. Benton, B. T. Putnam, Bailey Willis and W. M. Chauvenet. The opening general essay, by Pumpelly, is the best and most complete discussion yet published on the iron-ores of the United States, and gives much that is suggestive as regards their origin. The remainder of the report contains a detailed account of the mines by States, beginning with Maine and working westward. The report also contains a short paper by N. S. Shaler on the Mica Mines of New England, p. 833.

Reference has already been made to the series of reports by the U. S. Commissioner of Mineral Statistics. (See the *QUARTERLY*, July, 1889, p. 331.) After the publication of these was suspended, the annual reports of the Director of the Mint covered much the same field. For several years, however, the latter have been only statistical of the precious metals, as the other ground is fully covered by the volumes of the U. S. Geological Survey on Mineral Resources.

APPENDUM.—In the mention of the individual works above, the results attained by the synthetic experiments of the French should have been referred to. This branch of mineralogy has been especially cultivated among them, and is interesting, in that it throws much light on the processes by which minerals have formed in nature. The *Études Synthétiques de Géologie Expérimentale*, Paris, 1879, of A. Daubrée, has several opening chapters devoted to ore-deposits. Tin-ores are first treated. The very general association of fluorine and boron compounds with tin gave a hint as to the line of experiment. As tin fluoride was not readily accessible, tin chloride was vaporized and introduced into a heated porcelain tube or crucible, together with steam or with carbonic acid. In each case, artificial cassiterite resulted, and later, by a similar synthesis of phosphorus-pentachloride over quicklime, apatite was formed. A compound corresponding to topaz resulted in another experiment from the proper combinations of substances. From this the argument is made that the tin has been introduced into its veins as a fluoride, and then has been deposited as oxide, while the other minerals containing fluorine resulted in parallel reactions. A second portion relates to veins of sulphide ores, and is based on the writer's investigations of the minerals, which were found to

have formed within the historic period at the old Roman baths of Bourbonne. The warm springs contain sulphates of the alkalis and alkaline earths, bromides and carbonates of lime and iron, some alkaline silicates, and traces of many rarer elements. The interesting reactions took place on coins and other metallic objects which had been thrown into the principal spring by visitors from the time of Augustus on. Four thousand seven hundred recognizable gold, silver and bronze coins were obtained, and traces of many others remained in casts. Twenty-four different minerals were identified, among them, ores of copper, lead and iron which had resulted from the action of the spring water on the coins, etc. A subsequent chapter treats of platinum-deposits.

Mention should also be made of the volume by Fouqué and Lévy on the *Synthèse des Minéraux et des Roches*, Paris, 1882, in which is a detailed statement of all the artificial experiments in the formation of the various minerals made up to that date, with notes on their application to veins. The *Handbuch der Mineralogie* of Dr. Carl Hintze now being issued in parts, brings the same subject down to date.

In the foregoing brief review the attempt has been made to give an intelligible account of the progress of scientific thought as applied to ore-bodies in order that in a connected perusal the broader development of the subject might be traced from its beginning to the present time. Right conceptions and standpoints can thus be formed from which to formulate further hypotheses. The literature needs additions, especially from those in position to make observations, and for such it is hoped the review may prove useful. Naturally no complete and detailed bibliography is given, for which there has been no room, and in the plan of the paper such could not find a proper place.

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PROPERTIES OF PRECIPITATES, ETC.

BY E. WALLER, PH.D.

ONE division of Fresenius' book on *Quantitative Analysis* treats of "Forms," in which are given the properties of the various forms in which substances are separated for the purpose of weighing and determination.

It has seemed to the writer that those properties might be described in a manner more convenient for reference and also that there might be added the properties of various precipitates, etc., which are used in analytical work for purposes of *separation*. Of course, only those properties are considered which have a bearing on the usual manipulation of the different substances. For convenience the information has been grouped under the heads:

"*Remarks*" (*Rem.*), giving points not properly belonging under any of the succeeding heads.

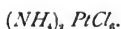
Conditions (*Cond.*), referring to the character of the solutions in which the separation can be made.

Solubilities (*Sol.*), under which the influences of different solvents which may be used in ordinary work are considered.*

Contaminants (*Contam.*), which is restricted to those substances only which would not be expected to precipitate if alone under the conditions obtained.

Ignition (*Ign.*), or the behavior of the compounds designated on heating to a high heat in the way usually pursued with most of them. Under this head it is also necessary to consider the effect of ignition in contact with filter-paper or other carbonaceous substances indicated for brevity as "C."

A table is given which is intended to indicate at a glance the precipitates, etc., used and the forms in which they are weighed in case that is the object in view. Of course, the forms designated as for *weighing* can also be used for purposes of *separation*.



Rem.—Precipitant, $PtCl_4$.

Yellow, perceptibly crystalline if formed slowly. Sometimes it is dissolved from the paper by hot water into a weighed capsule, and the solution evaporated, thus avoiding the uncertainties involved in the use of weighed filters.

Cond.—Solution should contain only chlorides. Sodium salts only permissible. Solution should be cold, slightly acid, con-

* The terms "soluble" and "insoluble," as used in text-books of analytical chemistry are usually misunderstood by students. The terms are used in a relative—not in an absolute—sense, e.g., when a precipitate is said to be "insoluble" the meaning usually is that under ordinary conditions of work, with a moderate bulk of solution, etc., the degree of solubility is so small that no material error is involved by regarding the separation as complete.

Element, etc.	Purpose.	Obtained, or Precipitated as	Prepared for Weighing by	Weighed as
NH ₄	Weighing.	(NH ₄) ₂ PtCl ₆	{ Drying. Ignition.	(NH ₄) ₂ PtCl ₆ or Pt
K	"	K ₂ PtCl ₆	{ Drying or Ignition.	K ₂ PtCl ₆ or Pt
	"	KCl	"	KCl
Na	"	K ₂ SO ₄	"	K ₂ SO ₄
	"	NaCl	"	NaCl
	"	Na ₂ SO ₄	"	Na ₂ SO ₄
Ca	"	CaC ₂ O ₄	{ " " "	CaSiO ₃ CaCO ₃ CaO
Mg	Separation. Weighing.	CaCO ₃ MgNH ₄ PO ₄	"	Mg ₂ P ₂ O ₇
Ba	Separation. Weighing. Separation.	Mg(OH) ₂ BaSO ₄ BaCO ₃	"	BaSO ₄
Fe	Weighing.	Fe ₂ (OH) ₆	"	Fe ₂ O ₃
Al	Separation. Weighing.	Fe(OH) ₃ (C ₂ H ₃ O ₂) ₉₋₁₀ Al ₂ (OH) ₆	"	Al ₂ O ₃
	"	Al ₂ (PO ₄) ₃	"	Al ₂ (PO ₄) ₃
Cr	Separation. Weighing.	Al ₂ (OH) ₆ (C ₂ H ₃ O ₂) ₆₋₈ Cr ₂ (OH) ₆	"	Cr ₂ O ₃
Ti	"	H ₂ TiO ₃	"	TiO ₂
	Separation.	Na ₂ TiO ₃		
Zn	Weighing.	2ZnCO ₃ ·3Zn(OH) ₂	"	ZnO
	"	ZnNH ₄ PO ₄	{ " " "	{ Zn ₂ P ₂ O ₇ ZnNH ₄ PO ₄
Mn	Separation. Weighing.	ZnS·H ₂ O 2MnCO ₃ ·H ₂ O	Ignition.	Mn ₂ O ₃
	"	MnNH ₄ PO ₄	"	Mn ₂ P ₂ O ₇
Ni	Separation. Weighing.	MnO ₂ Ni(Electro)	Drying.	Ni
	"	Ni(OH) ₂	{ Ignition.	NiO
	"	Ni ₂ (OH) ₆		
Co	Separation. Weighing. Separation.	NiS·H ₂ O 6KNO ₂ ·Co ₂ NO ₂) ₆ CoS·H ₂ O	Ignition.	3K ₂ SO ₄ +2CoSO ₄
Cu	Weighing.	Cu(Electro)	Drying.	Cu
	"	Cu(OH) ₂	Ignition.	CuO
	"	CuS	"	Cu ₂ S
Pb	Weighing.	PbSO ₄	Ignition.	PbSO ₄
	"	PbCrO ₄	Drying.	
Ag	Separation. Weighing.	PbS AgCl	Ignition.	AgCl
As	"	As ₂ S ₃	Drying.	As ₂ S ₃
	"	MgNH ₄ AsO ₄	Ignition.	Mg ₂ As ₂ O ₇
Sb	"	Sb ₂ S ₃	{ Ignition. Drying.	Sb ₂ O ₃ Sb ₂ S ₃
Sn	"	{ H ₁₀ Sn ₂ O ₁₅ SnS ₂	{ Ignition.	SnO ₂
S, SO ₂ , S ₂ O ₃ , SO ₃ etc. P, P ₂ O ₅ etc.	{ Weighing. Weighing. Separation.	BaSO ₄ MgNH ₄ PO ₄ 12MoO ₃ (NH ₄) ₄ PO ₄ + Na ₂ CO ₃ ·K ₂ CO ₃ etc. or Na ₂ CO ₃ +CaCO ₃	{ " " " Absorption.	BaSO ₄ Mg ₂ P ₂ O ₇ Na ₂ CO ₃ ·K ₂ CO ₃ etc. or Na ₂ CO ₃ +CaCO ₃
C, CO ₂ etc.	Weighing {	BaCO ₃		BaSO ₄
Si & SiO ₂	"	xH ₂ O·SiO ₂	Ignition.	SiO ₂
Cl	"	AgCl	"	AgCl
N & HNO ₃	Measuring Titration. Weighing.	N or NO NH ₃ (NH ₄) ₂ PtCl ₆		(NH ₄)PtCl ₆ or Pt

sisting chiefly of strong alcohol; an excess of PtCl_4 should be present.

Sol.—Somewhat soluble in cold, more so in hot, water. Fairly insoluble in strong alcohol, though more soluble than the corresponding potassium compound. Solubility in alcohol diminished by addition of ether. Its solubility also increases more rapidly by a rise in temperature or the dilution of the alcohol. Solubility increased by acid (HCl) or by alkali, diminished by PtCl_4 or Na_2PtCl_6 .

Contam.— NaCl which is not very soluble in alcohol. If sufficient PtCl_4 has been added to form Na_2PtCl_6 , the amount of contamination is small. The Na_2PtCl_6 crystals are more strongly colored and different in shape (needle-shaped) so that they can be readily detected. Can be removed by a short digestion with cold alcohol.

Ign.—Decomposed, leaving spongy platinum. Unless the heat is slowly raised some Pt may be volatilized with the products of decomposition.

KCl.

Rcm.—Obtained by evaporation of the solution, and gentle ignition. Frequently, when in admixture with NaCl , the sum of the chlorides is thus obtained, and the KCl determined by PtCl_4 , the NaCl calculated, or the chlorine is determined and the proportions calculated. Salts containing K combined with acids capable of expulsion by HCl , may be evaporated with excess of HCl .

Cond.—Solution should contain only chloride or salt convertible into chloride by evaporation with HCl . Ammonia salts and such others as may be expelled by evaporation and gentle ignition may be present.

Sol.—Soluble in water, less so in alcohol or strong HCl .

Contam.— NaCl , see under remarks. If the solution has been long exposed to the air of the laboratory, it usually contains some organic dust, which carbonizes by ignition, requiring filtering and re-evaporation.

Ign.—Decrepitates somewhat unless dried for some time. Fuses at a low red heat, and volatilizes at temperatures a little higher, a small amount of caustic alkali being usually formed at the same time.

K_2SO_4 .

Rem.—Obtained by evaporation of the solution, or by adding H_2SO_4 to solutions containing combinations with volatile acids (chloride, nitrate, acetate, etc.), evaporating and igniting. In cases of admixture with Na salts, processes similar to those indicated under KCl may be used.

Cond.—Salts forming non-volatile sulphates, or containing non-volatile acids (H_3PO_4 , etc.), should be absent.

Sol.—Moderately soluble in water; much less so in alcohol.

Contam.— Na_2SO_4 or other non-volatile sulphates.

Ign.—Practically non-volatile in the heat of an ordinary Bunsen burner if the heat is not unnecessarily prolonged. Where the solution has contained an excess of H_2SO_4 , some undecomposed $KHSO_4$ always remains, which can be best decomposed, or converted into K_2SO_4 by heating with a few lumps of solid ammonium carbonate. Ignited with C, K_2S may be formed. The conditions usually obtained, however, do not afford this result.

K_2PtCl_6 .

Rem.—Precipitant, $PtCl_4$.

More strongly colored than the corresponding ammonium salt, but otherwise resembling it in general characters. Like that compound, it is sometimes dissolved in hot water, and the solution evaporated in a weighed capsule, so as to dispense with weighed filters.

Cond.—Solution should be cold, alcoholic, and should contain preferably only sodium salts other than KCl. Chlorides or HCl should be present. Small amounts of Mg or Ca are permissible, though disadvantageous.

Sol.—Somewhat soluble in cold, more so in hot water. Insoluble in strong alcohol and in ammonium salts. Solubility increased by acid or alkali, diminished by $PtCl_4$ or Na_2PtCl_6 .

Contam.—NaCl and other salts (as sulphates) not soluble in alcohol. Such contaminants are most readily removed by washing with aqueous solution of NH_4Cl , previously saturated with K_2PtCl_6 .

Ign.—Alone, it is imperfectly converted to KCl and spongy platinum; with a reducing agent (as $H_2C_2O_4 \cdot 2H_2O$), the conversion is complete. The heat should not be too rapidly raised. If ignited in platinum too high a heat may fuse the finely divided metal

to the platinum vessel. After ignition, the KCl formed must be washed off with water before weighing.

NaCl.

Rem.—See *Rem.* under KCl.

Cond.—As for KCl.

Sol.—Soluble in water; much less so in strong HCl or alcohol. Less soluble in these menstrua than KCl.

Contam.—KCl (see KCl) or other non-volatile salts.

Ign.—Decrepitates violently on heating unless very thoroughly dried. Fusible at full red heat and volatilized at a temperature but little above its point of fusion. The temperatures of fusion and volatilization are, however, perceptibly higher than with KCl. Becomes slightly alkaline on fusion from loss of Cl.

Na₂SO₄.

Rem.—The suggestions as to K₂SO₄ throughout are applicable also to Na₂SO₄ (see K₂SO₄) even to the formation of NaHSO₄ by evaporation with excess of H₂SO₄ and ignition.

CaC₂O₄.

Rem.—Usual precipitant (NH₄)₂C₂O₄. The solution of the reagent had best be boiling hot when added. Precipitated cold or in very dilute solutions, it separates in a very fine powder. In any case, boiling for a short time and then adding a few drops of ammonia is advisable before proceeding to filter. If precipitated in boiling alkaline solution, the solution bumps vigorously. Enough oxalate should be added to convert all Mg present into Mg₂C₂O₄.

Cond.—Best precipitated in a boiling neutral solution, which should contain only Mg and alkalis besides the Ca.

Sol.—Dissolved by mineral acids, slightly soluble in acetic. Somewhat soluble in MgCl₂. Insoluble in MgC₂O₄. From its solutions in mineral acids, ammonia or other alkalis precipitate it unchanged.

Contam.—MgC₂O₄ which is removed by re-solution in HCl and reprecipitation by ammonia. If the proportion of Mg present is large this re-solution and reprecipitation may have to be repeated two or three times. Precipitating in a solution *barely acid* with HCl is most effective in separating from Mg.

Ign.—Affords first CaCO_3 , afterward CaO . Under ordinary circumstances the product is a mixture of the two. To obtain CaO it is necessary to ignite for some time over a blast-lamp. To obtain CaCO_3 , it is ignited moderately, and repeatedly moistened with ammonium carbonate and gently ignited after each addition.

Ignited with H_2SO_4 it affords CaSO_4 , which is frequently partially reduced to CaS by ignition with C , requiring further treatment with H_2SO_4 and ignition. The easiest mode of management is to transfer the filter paper containing the precipitate still wet to an ordinary fusion crucible, and wet down with concentrated nitric and sulphuric acids. Then expel the excess of acid with a gentle heat, and finally ignite. A second treatment with H_2SO_4 is often necessary. Instead of H_2SO_4 , a strong solution of $(\text{NH}_4)_2\text{SO}_4$, containing free ammonia and about 2 gms. NH_4Cl per 100 c.c., has been recommended (*vid.* Crooke's *Select Methods* 2d ed., p. 47).

CaCO_3 .

Rem.—Usual precipitant $(\text{NH}_4)_2\text{CO}_3$. For separation or determination of CO_2 , the reagent is CaCl_2 with ammonia. Usually obtained for separation. At first it separates in flocculent or amorphous form, but after a short time assumes a crystalline form. This change is hastened by warming gently.

Cond.—Large proportions of alkaline salts, especially citrates, and of magnesium salts should be avoided. An alkaline solution is, of course, necessary.

Sol.—Soluble in water containing CO_2 ; very soluble in all acids; decomposed and dissolved by NH_4Cl , slowly in the cold, quickly if hot. Insoluble in water containing ammonium carbonate with ammonia.

Ign.—Converted to CaO as described under $\text{Ca}_2\text{C}_2\text{O}_4$. The change is more readily effected if some carbon is mixed with it.

$\text{MgNH}_4\text{FPO}_4$.

Rem.—Usual precipitant for Mg — Na_2HPO_4 ; for P_2O_5 (ortho) — "magnesia mixture," preferably that made with MgCl_2 .

Should be crystalline; if flocculent, some contaminant is present. When the proportion of precipitate which can form is small relatively to the bulk of the solution, some hours are necessary for complete separation.

Completeness of precipitation much accelerated by cold and agitation.

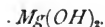
When washed as usual with diluted ammonia, alkaline phosphate (Na_2HPO_4 , etc.) is not very rapidly removed, the salt being less soluble in ammonia than in water.

Cond.—Absence of silica or any bases other than alkalis. NH_4Cl or ammonium salts should be present.

Sol.—Solution should be cold for precipitation and filtration. Soluble in acids, even when weak, in hot solutions and, to some extent, in cold water; insoluble in dilute ammonia.

Contam.—Silica and $\text{Mg}(\text{OH})_2$ or basic salts of Mg. The latter is only likely to occur when the precipitate is used for the purpose of determining P_2O_5 or P. The difficulty is avoided by adding the Mg mixture (preferably the chloride) slowly with stirring. Silica may be weighed and deducted after ignition, weighing and dissolving in acid. MoO_3 may also occur when the molybdate separation has preceded.

Ign.—Should be well dried before igniting. If heated too rapidly some loss may result from too rapid decomposition. If the filter paper is allowed to burn with flame, some particles of the precipitate (in weighable amount) may be mechanically carried off. The precipitate has afterward a tendency to sinter together at a moderately high heat, thereby preventing the oxygen of the air from penetrating the mass and oxidizing the carbon, the precipitate being left gray or black. The best mode of managing is to expose the precipitate for some time to a dull red after the carbonization of the paper, and finally, finish with the full heat of the Bunsen burner. If the precipitate comes black, repeated moistening with nitric acid and cautious ignition is to be recommended.



Rem.—Usual precipitant $\text{Ba}(\text{OH})_2$ for separation from alkalis when these are to be determined. The $\text{Ba}(\text{OH})_2$ should be tested for NaOH , which is not infrequently present.

Cond.—Alkaline solution moderately concentrated, containing no NH_4 salts.

Sol.—Dissolved by acids or ammonia salts. Precipitation partly prevented by presence of organic salts, citrates, tartrates, sugar, etc.

Contam.—Usually unimportant, the object generally being to

remove from the solution MgO and all substances except those readily separable by ammonium carbonate.

BaSO₄.

Rem.—Precipitant for $\text{SO}_3\text{—BaCl}_2$; for Ba — H_2SO_4 .

Precipitated in an extremely fine state of division (runs through filter paper) if formed in cold or dilute solutions, or such as contain ammonia salts. Forms slowly if small in amount.

The tendency of the precipitate to creep up the side of a beaker may be checked by adding a drop of HCl.

Cond.—Hot solution acidified with HCl. Hydro-fluo-silicic acid or silica should be absent, also large proportions of calcium salts, or salts of the $(\text{NH}_4)_2\text{S}$ group of bases.

Sol.—Soluble in concentrated H_2SO_4 , in HCl when moderately strong and hot, and in HNO_3 even when tolerably dilute. It is also soluble in hot Fe_2Cl_6 , in alkaline and alkaline earth nitrates, citrates, and salts of some other organic acids.

Insoluble in water, in (very) dilute HCl, and in acetic acid.

Contam.—The especial difficulty with BaSO_4 is its tendency to carry with it other substances, as alkaline, and alkaline earth nitrates, chlorates, sulphates and chlorides. Potassium salts give more trouble in this respect than sodium salts. The precipitate may also contain silica, and basic ferric, aluminic or chromic compounds.

Repeated boiling up with very dilute HCl, assists in removing some of these to a considerable extent, though there is some danger of dissolving some of the precipitate by this treatment. Washing alternately with hot dilute HCl, and with cold water, is often advantageous. Stolba's method of purifying the precipitate consists in digesting (after washing) for ten to fifteen minutes at a boiling-heat, with 40 to 50 c.c. of cold saturated solution of $\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2$ and acetic acid, filtering and washing free from Cu (*vid. Crooke's Select Methods*, 2d. ed., p. 492). Sloane recommends for purification from iron, to decant the supernatant liquid closely, then add 5 or 10 c.c. of concent. HCl, and boil for one minute, dilute, and after nearly neutralizing with ammonia, filter and wash thoroughly (*Jour. Am. Chem. Soc.*, iii., 37). Archbutt advises to precipitate warm (not boiling), allow to stand until thoroughly cold, and the precipitate has settled well, then to filter and wash with cold water (*Jour. Soc. Chem. Ind.*, ix., 25). Jannasch and Richards

assert that no correct determination of SO_3 can be made in the presence of Fe, because the precipitate always contains more or less of a double barium iron sulphate, from which SO_3 is expelled on ignition. To avoid errors they therefore recommend the previous removal of the iron by ammonia (*Jour. Pr. Chem.* [2], xxxix., 321), (*vid. also Lunge, Zts. Angew. Chem.*, 1880, 473). Ziegeler (*Pharm. Centr.*, 1881, p. 555) recommends the addition of some AgNO_3 to the solution (containing chloride) that the AgCl may enclose, and carry with it the particles of BaSO_4 . After washing with water the AgCl may be dissolved off with ammonia.

Ign.—With C some BiS invariably forms. The difficulty may be remedied by adding a few drops of fuming HNO_3 to re-oxidize the S, and igniting again, or better by re-igniting after the addition of a drop or two of conc. H_2SO_4 .



Rem.—At first amorphous, it assumes almost immediately the crystalline form in which condition it does not affect alkalimetric indicators.

Cond.—Alkaline solution.

Sol.—Soluble in water containing CO_2 and in acids. Also taken into solution by NH_4Cl and some other ammonium salts, especially on boiling. Insoluble in a mixture of ammonium hydrate and carbonate.

Contam.— MgCO_3 if much is present, and carbonates of fixed alkalis if present.

Ign.—Converted imperfectly to BaO , unless mixed with carbon, when the change occurs readily.



Rem.—Precipitation in most cases effected by NH_4OH .

When but little ferrous iron is present, and heat is applied, a finely-divided red ("brick-dust") precipitate separates, which is insoluble except in concentrated HCl .

In presence of a larger proportion of ferrous salt, black $\text{Fe}_3(\text{OH})_8 = \text{Fe}(\text{OH})_2, \text{Fe}_2(\text{OH})_6$ will separate. With more ferrous salt the precipitate is green, the color being lighter the larger the proportion of ferrous salt; and when the iron is all absolutely in the ferrous form, the precipitate is white. Whenever ferrous salt is present, a double ammonium ferrous salt forms, which remains in solution, from

which the iron slowly precipitates by absorption of oxygen, and conversion to the ferric form. NH_4Cl favors the precipitation of $\text{Fe}_2(\text{OH})_6$.

Cond.—Iron should be in ferric form. H_2S should be absent.

Sol.—Soluble in acids and in solution containing citric, tartaric acids, etc., as well as other organic substances, glycerine, sugar, etc. Insoluble in alkalis.

Contam.—Basic ferric salts, especially basic sulphate, unless the precipitant is in moderate excess. When precipitated by fixed alkalis, the precipitate contains some alkali, which is washed out with great difficulty. Precipitate will carry with it phosphoric acid as $\text{Fe}_2(\text{PO}_4)_2$ in nearly sufficient quantity to form that compound. The excess of phosphoric acid will remain in solution unless some other base (Al, Ca, etc.) is present to carry it down in combination. Precipitate may also contain nearly if not quite all of the Al, Mn and silica present. Mg, Co, Ni, Zn and Cu are also liable to be present in the precipitate, Ca also as CaCO_3 if the alkaline solution has absorbed any CO_2 from the atmosphere. From these latter (Mg, etc., including Ca), the precipitate may be freed by one or more resolutions and reprecipitations.

Ign.—Converted to Fe_2O_3 . With C, a partial reduction to Fe_3O_4 may occur. Fe_2O_3 is restored by adding a few drops of HNO_3 , and reignition. In contact with NH_4Cl , may form volatile Fe_2Cl_6 .

$\text{Fe}_2(\text{OH})_6(\text{C}_2\text{H}_3\text{O}_2)_6$. Basic Ferric Acetate.

Rem.—Ferrous salts, if present, are not precipitated. If in very small proportion, they may induce the formation of the "brick-dust" precipitate alluded to under $\text{Fe}_2(\text{OH})_6$. In analysis of iron-ores and manufactured irons, the reduction of the major part of the iron to the ferrous form, and application of the basic acetate, separation is frequently resorted to in order to remove the excess of iron, before determining phosphorus.

Cond.—The *dilute* solution should contain but little free acetic acid. The (ferric) iron should be in the form of acetate. This is obtained by neutralizing the free mineral acid present and adding $\text{NaC}_2\text{H}_3\text{O}_2$. No precipitate should appear in the cold, but on boiling a few minutes (three to five) it separates completely, provided, not too much free acetic acid is present. *Too-long boiling* causes the precipitate to assume a form which filters with some difficulty.

Sol.—Soluble in cold dilute acetic acid and in mineral acids, also in citrates, and other organic substances mentioned as solvents of $\text{Fe}_2(\text{OH})_6$.—Insoluble in hot acetic acid only when quite dilute.

Contam.—Salts of fixed alkalies. Silica, aluminina salts, and P_2O_5 , the latter in the form of $\text{Fe}_2(\text{PO}_4)_2$ [see $\text{Fe}_2(\text{OH})_6$]. The precipitate may also contain some Mn, Zn, Ni, Co or Cu. Mn is more likely to be present if the amount of $\text{NaC}_2\text{H}_3\text{O}_2$ added was large. The amounts of these last in the precipitate is much diminished by increasing the proportion of free acetic acid in the solution. The danger of having sufficient free acid to prevent the precipitation of all the iron is, however, considerable. By redissolving in HCl, neutralizing, adding $\text{NaC}_2\text{H}_3\text{O}_2$ and reprecipitating, the Zn, Ni, etc., can be removed. Zn usually gives the most trouble. If much is present, it may be advisable to precipitate in a solution containing enough free (acetic) acid to hold a little Fe in solution. The latter may be separated by evaporating the excess of acid from the filtrate. SiO_2 and Cu should be previously removed by known methods, if their presence in the precipitate will influence subsequent work.

When chromium is present in the solution, the action is peculiar. When iron predominates decidedly, all of the chromium is precipitated with it. If the ratio of chromium to iron is nearly the same, not only much of the chromium, but some of the iron is retained in the solution.



Rem.—In general terms the precipitate is very similar to $\text{Fe}_2(\text{OH})_6$ but is more easily prevented from forming, and when separated, being more gelatinous in character, is less readily managed. Usual precipitate, ammonia. A good method of managing consists in rendering slightly alkaline with ammonia, and passing H_2S , raising the temperature at the same time gradually to boiling.

Cond.—Neutral or slightly alkaline solution, containing preferably NH_4Cl .

Sol.—Dissolves in acids, and in fixed caustic alkalies; somewhat soluble in ammonia, especially in the cold. From this solution it may be separated by boiling out the major part of the NH_3 , particularly if NH_4Cl is present. Precipitation prevented by presence of tartrates, citrates, sugar, glycerin, etc. After boiling or standing for a short time, the precipitate will dissolve in acids (even HCl) slowly and with some difficulty.

Contam.—Basic Al salts, especially the sulphate. Retains P_2O_5 in proportion sufficient to form $Al_2(PO_4)_3$. May also contain Fe, Mn or SiO_2 (hydrated). Possibly, also, Mg, Zn, Co, Ni, Cu, etc., from which last it may be freed by resolution and reprecipitation except, perhaps, in the case of Zn, from which a complete separation of $Al_2(OH)_6$ can scarcely be effected. Ca may also accompany it as $CaCO_3$ if the alkaline solution has absorbed CO_2 .

Ign.—Converted to Al_2O_3 . Ignited with NH_4Cl some volatile Al_2Cl_6 may form. After ignition practically insoluble in HCl. Converted to a soluble form by fusion with an alkaline flux.

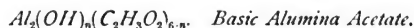


Rem.—Of service in the determination of Al in manufactured irons and in mineral phosphates.

Cond.—Fe, if present, should be in the ferrous form. The conditions usually produced are a solution acid with acetic, in which Fe has been reduced by $Na_2S_2O_3$, and containing an excess of alkaline phosphate. This is boiled for some time.

Sol.—Dissolves in mineral acids. Insoluble in moderately strong $H_2C_2O_4$. Prevented by tartrates, citrates, etc., in the same way as $Al_2(OH)_6$.

Contam.— $Fe_2(PO_4)_3$ and possibly basic ferric salt. If Fe is kept entirely in the ferrous condition (which is not always possible) this contamination would not occur. Remedied by redissolving, reducing and reprecipitating. $Ca_3(PO_4)_2$ (or alkaline salts if the solution is not sufficiently dilute) may also accompany the precipitate. Remedy by resolution and reprecipitation. Glaser's method for mineral phosphates involves the previous separation of the lime, as $CaSO_4$, by the aid of alcohol (*Zts. Angew. Chem.*, 1889, p. 636).



Rem.—Very similar to the corresponding Fe compound. Being more slimy in character, it gives more trouble in filtering and general management. Used for separation only.

Cond.—The same as for the Fe compound. Practically no free acetic acid is admissible. Al should be in the form of acetate. Precipitate obtained by boiling. If boiled too long, it filters and washes with more difficulty.

Sol.—Dissolves in acids, to some extent in very dilute boiling

acetic. If the solution after boiling is allowed to cool, a considerable proportion redissolves. Soluble, or precipitation prevented by citrates, tartrates, etc. The small amount almost invariably remaining in the filtrate may be recovered by careful neutralization and boiling, or better by evaporating to dryness, and taking up with dilute acetic.

Contam.—As for the Fe compound. Salts of fixed alkalies, P_2O_5 [in proportion sufficient to form $Al_2(PO_4)_3$], SiO_2 (hydrated), Mn, Zn, etc.



Rem.—In general properties this precipitate resembles $Al_2(OH)_6$ and its management is similar. Its tendency to carry with it other substances, requires that it shall always be redissolved and reprecipitated with ammonia at least twice.

Cond.—Absence of members of $(NH_4)_2S$ groups and preferably of all non-volatile salts. Solution must be exactly neutral (ammonia added in slight excess and then boiled until neutral). NH_4Cl assists the separation.

Sol.—Dissolves in all acids, in fixed alkaline hydrates and perceptibly in excess of NH_4OH . Soluble or prevented from precipitating by tartrates, citrates, sugar, etc.

Contam.—Salts of fixed alkalies, alkaline earths, members of the $(NH_4)_2S$ group, etc. (See above, *Rem.*)

Ign.—Converted to Cr_2O_3 , in which form, if strongly ignited, it becomes insoluble in HCl . In presence of fixed alkalies or alkaline salts and in contact with the oxygen of the air, is partially or entirely converted to chromate.

(To be continued.)

STUDY OF A METHOD FOR THE QUANTITATIVE
DETERMINATION OF SUCROSE, INVERT-
SUGAR, AND DEXTROSE, OR
LEVULOSE.

By F. G. WIECHMANN, Ph.D.

PART II.

FOR reasons indicated in Part I. of this article,* a careful investigation was made concerning the various conditions which affect the destruction of the levulose on treatment with hydrochloric acid. It soon became patent that in order to gain a clear understanding of the problem, like attention would have to be given to the behavior of invert-sugar and of dextrose, under similar conditions; in consequence, this investigation was extended considerably beyond the limits originally intended.

The results obtained are recorded in seven "Series of Experiments," which are given below:

For valuable and conscientious work performed in the securing of these data, the writer acknowledges his indebtedness to his assistants, Messrs. Brainerd and Ziebolz.

All determinations refer to 0.25 gramme, dry substance.

Invert-sugar, dextrose, and levulose were each separately studied with reference to variations in:

- a. The time of boiling.
- b. The amount of acid.
- c. The time of boiling against the amount of acid.

These tests are given in Series 1, 2, and 3.

Series 4 and 5, treat of the behavior, under like variations of condition, of mixtures of invert-sugar and dextrose, and of invert-sugar and levulose 94.0 per cent. of the former to 6.0 per cent., respectively, of dextrose and of levulose.

Series 6 exhibits the behavior of invert-sugar and dextrose, mixed in different proportions, when exposed under the same conditions as to time of boiling and amount of acid present.

Series 7 shows a parallel set of tests, carried out on corresponding mixtures of invert-sugar and levulose.

* THE SCHOOL OF MINES QUARTERLY, vol. xi., No. 3, 1890.

SERIES I.—INVERT-SUGAR.

0.25 gramme of dry substance used in each experiment.

Condition varied; Time of Boiling.		Condition varied; Amount of Acid.		Conditions varied: Time of Boiling and Amount of Acid.	
60 C.C. HCl (6 x normal strength) were used in each experiment.		Time of Boiling: Four hours in each experiment.			
Time of boiling, in hours.	If all levulose, and <i>only</i> levulose, were destroyed, there would be reduced of Cu = 0.2355. There <i>were</i> reduced of Cu:	Amount of HCl (6 x normal strength) used.	If all levulose, and <i>only</i> levulose, were destroyed, there would be reduced of Cu = 0.2355. There <i>were</i> reduced of Cu:	Time of boiling, in hours; amt. of HCl (6 x normal strength) used.	If all levulose, and <i>only</i> levulose were destroyed, there would be reduced of Cu = 0.2381. There <i>were</i> reduced of Cu:
1	0.2632 } 0.2675 } 0.2668 0.2698 }	30 C.C.	0.2564 } 0.2609 } 0.2587	3 hours. 120 C.C.	0.2223 } 0.2254 } 0.2239
2	0.2546 } 0.2591 } 0.2568	60 C.C.	0.2350 } 0.2362 } 0.2356	6 hrs. 60 C.C.	0.2290 } 0.2300 } 0.2295
3	0.2490 } 0.2492 } 0.2491	90 C.C.	0.2147 } 0.2184 } 0.2166		
4	0.2350 } 0.2362 } 0.2356				
6	0.2232 } 0.2267 } 0.2249				

Inspection of Series No. 1, invert-sugar, teaches:

1. That, working with the prescribed amount of hydrochloric acid, of six times the normal strength, a boiling-time of four hours is necessary to effect complete destruction of the levulose present.

2. That, boiling continued beyond this time results in partial destruction of the dextrose.

3. That, the time of boiling being the same, the action which the acid exerts upon the invert-sugar is directly proportional to the amount of acid present; that is to say, insufficient acid will leave some levulose undestroyed; excess of acid will destroy some dextrose in addition to the levulose.

4. That, the time of boiling and the amount of acid used are directly interchangeable; that is to say, that practically the same results are obtained by boiling for three hours with 120 c.c. of acid as by boiling six hours with 60 c.c. of acid.

SERIES II.—DEXTROSE.

0.25 gramme dry substance used in each experiment.

Condition varied: Time of Boiling.		Condition varied: Amount of Acid.		Conditions varied: Time of Boiling and Amount of Acid.	
60 C.C. HCl (6 x normal strength) were used in each experiment.		Time of Boiling: Four hours in each experiment.			
Time of boiling, in hours.	If the dextrose were not attacked by the acid, there would be reduced of Cu = 0.4505. There were reduced of Cu:	Amount of HCl (6x normal strength) used	If the dextrose were not attacked by the acid, there would be reduced of Cu = 0.4505. There were reduced of Cu:	Time of boiling, in hours.	If the dextrose were not attacked by the acid, there would be reduced of Cu = 0.4505. There were reduced of Cu:
1	0.4323 } 0.4350 } 0.4337	30 C.C.	0.4282 } 0.4288 } 0.4285	3 h'rs. 120 C.C.	0.2914 } 0.2973 } 0.2944
2	0.4270 } 0.4296 } 0.4283	60 C.C.	0.3977 } 0.3986 } 0.3982	6 h'rs. 60 C.C.	0.2901 } 0.2929 } 0.2915
3	0.4153 } 0.4173 } 0.4163	90 C.C.	0.3852 } 0.3861 } 0.3857		
4	0.3977 } 0.3986 } 0.3984				
6	0.2901 } 0.2929 } 0.2915				

Inspection of Series No. 2 dextrose, shows:

1. That, dextrose in solution is attacked by hydrochloric acid of six times the normal strength.
2. That, the amount of acid used being constant, the amount of dextrose destroyed depends upon the length of time that the boiling is continued.
3. That, the amount of dextrose thus destroyed is not the same for corresponding periods of time, but rapidly increases as the time of boiling is prolonged. Thus, the difference in the amounts of copper reduced, is: Between one and two hours' boiling, 0.0054; between two and three hours' boiling, 0.0120; between three and four hours' boiling, 0.0179; between four and six hours' boiling, 0.1069.
4. That, the time of boiling being the same, the action which the acid exerts upon the dextrose is proportional to the amount of the acid present—the more acid, the more dextrose is destroyed.
5. That, the time of boiling, and the amount of acid used are, practically, interchangeable factors.

SERIES III.—LEVULOSE.

0.25 gramme dry substance used in each experiment.

Condition varied: Time of Boiling.		Condition varied: Amount of Acid.		Conditions varied: Time of Boiling and Amount of Acid.	
60 C.C. HCl (6 x normal strength) were used in each experiment.		Time of boiling: Four hours in each experiment.			
Time of boiling, in hours.	Untreated levulose reduces of Cu = 0.4290. If all levulose were destroyed no Cu would be reduced. There were reduced of Cu:	Amount of HCl (6 x normal strength) used.	Untreated levulose reduces of Cu = 0.4290. If all levulose were destroyed, no Cu would be reduced. There were reduced of Cu:	Time of boiling, in hours; amt. of HCl (6 x normal strength) used.	Untreated levulose reduces of Cu = 0.4228. If all levulose were destroyed, no Cu would be reduced. There were reduced of Cu:
1	0.2716 } 0.2731 0.2746 }	30 C.C.	0.2620 } 0.2630 0.2640 }	3 h'rs. } 120 C.C. }	0.0518 } 0.0545 0.0572 }
3	0.2082 } 0.2122 0.2162 }	60 C.C.	0.0878 } 0.0882 0.0886 }	6 h'rs. } 60 C.C. }	0.0468 } 0.0473 0.0477 }
4	0.0878 } 0.0882 0.0886 }	90 C.C.	0.0370 } 0.0373 0.0376 }		
6	0.0468 } 0.0473 0.0477 }				

Series No. 3, levulose, shows :

1. That, the amount of acid being constant, the amount of levulose destroyed depends upon the length of time that the boiling is carried on.

2. That, the time of boiling being constant, the amount of levulose destroyed is proportional to the amount of acid used.

3. That, the time of boiling, and the amount of acid used are, practically, interchangeable factors.

Series No. 4 and No. 5 (see pp. 253 and 254) exhibit the determinations made, respectively on mixtures of invert-sugar (94 per cent.) with dextrose (6 per cent.), and with levulose (6 per cent.).

Both series show :

1. That, the amount of acid remaining constant, the time of boiling determines the extent to which the sugars are decomposed.

2. That, the time of boiling remaining constant, the extent to which the decomposition is effected is dependent upon the amount of acid present.

3. That, the time of boiling, and the amount of acid used, are, practically, interchangeable factors.

All of these tests, made on mixtures of invert-sugar and dextrose, and invert-sugar and levulose, respectively, are simply confirmatory of the results obtained by the experiments made with these substances individually.

In addition to establishing these facts, Series 4 and 5 show—as was to be anticipated—that the length of time during which the

SERIES IV.—INVERT-SUGAR AND DEXTROSE.

(94.0 %.) + (6.0 %.)

0.25 gramme dry substance used in each experiment.

Condition varied: Time of Boiling.		Condition varied: Amount of Acid.		Conditions varied: Time of Boiling and Amount of Acid.	
60 C.C. HCl (6x normal strength) were used in each experiment.		Time of Boiling: Four hours in each experiment.			
Time of boiling, in hours,	If all levulose, and only levulose were destroyed, there would be reduced of Cu = 0.2526. There were reduced of Cu:	Amount of HCl (6x normal strength) used.	If all levulose, and only levulose were destroyed, there would be reduced of Cu = 0.2526. There were reduced of Cu:	Time of boiling, in hours, and of HCl (6x normal strength) used.	If all levulose, and only levulose were destroyed, there would be reduced of Cu = 0.2526. There were reduced of Cu:
1	0.2848 } 0.2856 0.2864 }	60 C.C.	0.2397 } 0.2413 0.2428 }	3 h'rs. } 0.2289 } 120 C.C. } 0.2300 }	0.2295
2	0.2570 } 0.2585 0.2600 }	120 C.C.	0.2080 } 0.2103 0.2126 }	6 h'rs. } 0.2298 } 60 C.C. } 0.2316 }	0.2307
3	0.2497 } 0.2515 0.2533 }				
4	0.2397 } 0.2413 0.2428 }				
6	0.2235 } 0.2253 0.2270 }				

boiling must be continued in order to destroy all of the levulose, depends upon the amount of levulose present. Thus, in the mixture consisting of invert-sugar 94 per cent., plus dextrose 6 per cent., three hours yield a result most closely approximating the theoretical value; and, in the case of the mixture of invert-sugar 94 per cent. and levulose 6 per cent., four hours were needed to obtain this approximation.

SERIES V.—INVERT-SUGAR AND LEVULOSE.

(94.0 %.) + (6.0 %.)

0.25 gramme dry substance used in each experiment.

Condition varied: Time of Boiling.		Condition varied: Amount of Acid.		Conditions varied: Time of Boiling and Amount of Acid.	
60 C.C. HCl (6x normal strength) were used in each experiment.		Time of Boiling: Four hours in each experiment.			
Time of boiling, in hours.	If all levulose, and only levulose, were destroyed, there would be reduced of Cu = 0.2356. There were reduced of Cu:	Amount of HCl (6x normal strength) used.	If all levulose, and only levulose were destroyed, there would be reduced of Cu = 0.2238. There were reduced of Cu:	Time of boiling, in hours: amt of HCl (6x normal strength) used.	If all levulose, and only levulose were destroyed, there would be reduced of Cr = 0.2238. There were reduced of Cu:
1	0.2865 } 0.2875 } 0.2870	60 C.C.	0.2280 } 0.2252 } 0.2266	3 h'rs. 120 C.C.	0.2182 } 0.2152 } 0.2167
2	0.2404 } 0.2416 } 0.2410	120 C.C.	0.1952 } 0.1986 } 0.1969	6 h'rs. 60 C.C.	0.2088 } 0.2108 } 0.2098
3	0.2347 } 0.2370 } 0.2359				
4	0.2280 } 0.2252 } 0.2266				
6	0.2088 } 0.2108 } 0.2098				

Series No. 6 and No. 7 (see pp. 255 and 256) show the effect of a constant amount of acid, with constant time of boiling, on different mixtures of invert-sugar and dextrose, and of invert-sugar and levulose.

The values obtained in series No. 6, with one exception (ratio 95:5), all show that *less* copper was reduced than should have been reduced.

The values in series No. 7 all show, without exception, that *more* copper was reduced than should have been reduced.

The significance of these data is evident.

In the case of invert-sugar (series No. 1), where the proportion of dextrose to levulose is as 1:1, four hours' boiling with 60 c.c. HCl (6x normal strength) resulted in a destruction of the levulose almost theoretically perfect.

Series No. 6 demonstrates that, if the substance operated upon, under the same conditions named above, does not consist of dex-

trose and levulose in the proportion 1 : 1, but contains an *excess* of dextrose, *dextrose as well as levulose* is destroyed.

Series No. 7 demonstrates that, if the substance operated upon under the same conditions, does not consist of dextrose and levulose in the proportion 1 : 1, but contains an *excess* of levulose, *the levulose is not all destroyed*.

It is therefore proved, that this method of analysis cannot serve

SERIES VI.—INVERT-SUGAR AND DEXTROSE.

0.25 gramme dry substance used in each experiment.

In each instance;

Time of Boiling, 4 hours. Amount of HCl (6x normal strength) = 60 C.C.

Ratio of Invert-Sugar to Dextrose.	If all levulose, and <i>only</i> levulose were destroyed, There would be reduced of Cu :	There <i>were</i> reduced of Cu :
50 : 50	0.3460	0.3215 } 0.3217 0.3218 }
60 : 40	0.3238	0.3106 } 0.3109 0.3112 }
90 : 10	0.2572	0.2560 } 0.2567 0.2573 }
94 : 6	0.2526	0.2397 } 0.2413 0.2428 }
95 : 5	0.2462	0.2484 } 0.2491 0.2498 }
98 : 2	0.2392	0.2365 } 0.2383 0.2380 } 0.2405 }

for the determination of the relative amounts of invert-sugar, dextrose, or levulose, when these occur together. The solution of this problem, if it is to be attempted on these lines, calls for the discovery of some reagent which will, under *all circumstances*, destroy absolutely the one of these sugars, dextrose or levulose, and not affect the other.

Such a reagent would prove of the greatest value for the study of important problems in connection with the sugar-industry, and by its aid we might also hope for the disclosure of some of the

SERIES VII.—INVERT-SUGAR AND LEVULOSE

0.25 gramme dry substance used in each experiment.

In each instance :

Time of Boiling, 4 hours. Amount of HCl (6x normal strength) = 60 C.C.

Ratio of Invert-Sugar to Levulose.	If all levulose, and <i>only</i> levulose were destroyed, There would be reduced of Cu :	There <i>were</i> reduced of Cu :
50 : 50	0.1177	0.1693 } 0.1718 } 0.1706
60 : 40	0.1413	0.1765 } 0.1770 } 0.1768
90 : 10	0.2119	0.2236 } 0.2247 } 0.2242
94 : 6	0.2238	0.2280 } 0.2252 } 0.2266
95 : 5	0.2233	0.2254 } 0.2263 } 0.2303 } 0.2307 } 0.2282
98 : 2	0.2308	0.2410 } 0.2410 } 0.2430 } 0.2440 } 0.2423

most closely-guarded secrets of nature's laboratory—the formation of saccharine juices in the vegetable kingdom.

JAMES BUCKTON MACKINTOSH.*

JAMES BUCKTON MACKINTOSH was born at Bebington, Cheshire, England, December 29, 1859. His mother died in England while he was a very young boy, and he was brought up by his father's niece, who took the education of the children after his mother's death. He was educated at Liverpool Institute schools, where he showed great promise, being head of his classes in mathe-

* See Frontispiece.

matics, chemistry, and electricity. At the local examination, held May, 1873, he passed first, and was declared, "An Associate in Arts of the University of Oxford." He also held a certificate issued by the Science and Art Department of the Council of Education of England. In August, 1873, his family removed to this country. Shortly after, he entered the School of Mines; from which he graduated in 1877, with the degree of E.M. and C.E. Immediately after graduation, he entered the Metallurgical Laboratory, where he remained until August, 1886, when he resigned to take the position of an instructor in chemistry at Lehigh University, Bethlehem, Pa. He had hardly begun the work in the Metallurgical Laboratory, before he commenced to develop original methods of investigation, and to show aptitude for research as well as accuracy of determination that was remarkable in so young a man, and foreshadowed the distinguished position that he occupied, and the much more distinguished position that all his friends think he would have occupied if his life had been spared. He very soon became an authority in all matters relating to analytical chemistry. By the time he left the Metallurgical Laboratory, it was full of ingeniously contrived apparatus and accurately devised methods for chemical research and mineralogical determination. He was amongst the first, and was one of the most prominent in devising new methods for accurately determining very minute amounts of the constituents of iron and steel, and of correcting errors of previous methods of analysis. When the colored gems came into fashion, he very quickly became an authority in determining them, and invented new, rapid, and accurate methods of distinguishing, not only between the false and the real, but also between the different varieties of all kinds of precious stones. It was not long before he became an expert in the determination and analysis of new and rare minerals, and his name will always be associated with some of the determinations of very uncommon constituents in some of the very rare minerals found for the first time in this country, such, for instance, as Herderite. His first analysis of this mineral was repudiated by both European and American experts; but it was not long before it was recognized that not only his analysis was correct, but his methods were more accurate than any of those which had been previously used; and from that time his work was unquestioned. When there came a commercial demand for the salts of the rare metals Thorium and Lanthanium, and the

preparation of Zirconium on a large scale, he was among the first to present practicable methods for their extraction from the minerals which contained them, and the preparation of their salts on a commercial scale.

Not being content with his position at Lehigh, after occupying it for some time, he left it on May 1st, 1888, to accept the position of chemist of the Consolidated Gas Company of New York, which position he occupied at the time of his death.

At the time of his death, he was a member of the American Institute of Mining Engineers, the American Chemical Society, the Society of Chemical Industry of London, and the Société Chimique de Paris. For the publications of these societies he made frequent contributions.

He was short in stature, but very quick and active in his physical movements as well as in his mental processes, and he was as accurate as he was quick. His manner was quiet and gentle. He took his ground in professional questions resolutely, and was rarely faulted in his determinations. In 1883 he was appointed one of the editors of the School of Mines QUARTERLY, taking the literary part of the work in the editorial department, and to his able editorship this review owes a great deal. He resigned the editorship in 1888, before he returned to New York, he being at that time in Bethlehem, and unable to attend to the duties of the editorial chair.

On the 29th of December, 1888, he married Miss Mary Hendforth. He died on April 15, 1891, leaving his widow with a boy fifteen months old. His loss will be greatly felt at the School of Mines, in the profession, and among his very many friends.

T. E.

The following is a possibly incomplete list of articles by Mr. Mackintosh:

Chemical News.

On the Determination of Graphite in Minerals, Vol. 51, p. 147.

Journal American Chemical Society.

On the Action of Hydrofluoric Acid on Silica and Silicates, Vol. VIII., p. 210.

American Chemical Journal.

The Electrolytic Determination of Copper, and the Formation and Composition of so-called Allotropic Copper, Vol. III., p. 354.

The Volumetric Determination of Manganese, Vol. V., p. 290.

A New Method for the Determination of Phosphorus in Iron and Steel, Vol. VII., p. 296.

An Improved Form of Elliott's Gas Apparatus, Vol. IX., p. 294.

American Journal of Science.

On Herderite, a Glucinum Calcium Phosphate and Fluoride, from Oxford County, Maine, Vol. 27, p. 135. With W. E. Hidden.

On the Composition of Herderite, Vol. 28, p. 401.

Titanic Iron Sand from Brazil, Analysis of, Vol. 29, p. 342.

On a New Thorium Mineral, Auerlite, Vol. 36, p. 461.

Native Iron Sulphates, from Chili, Vol. 38, p. 242.

Yttria and Thoria Minerals, from Llano County, Texas, Vol. 38, p. 474. With W. E. Hidden.

Eudialyte from Arkansas, Vol. 38, p. 494. With W. E. Hidden.

On the Occurrence of Polycrase, or of an Allied Species, in North and South Carolina, Vol. 39, p. 202. With W. E. Hidden.

Transactions of the Institute of Mining Engineers.

A New Method of Determination of Phosphorus in Iron and Steel, Vol. 14, p. 385.

Electrolytic Determination of Copper, and the Formation and Composition of the so-called Allotropic Copper, Vol. 10, p. 57.

Note on the Influence of Organic Matter and Iron on the Volumetric Determination of Manganese, Vol. 13, p. 39.

The Volumetric Determination of Manganese, Vol. 11, p. 79.

A Crystalline Subsulphide of Iron and Nickel, Vol. 17, p. 117.

School of Mines Quarterly.

Action of Hydrofluoric Acid on Silica and Silicates, Vol. VII., p. 384, Vol. VIII., p. 115.

Graphite, Determination of in Minerals, Vol., VI., p. 159.

Herderite a Calcium and Glucinum Phosphate and Fluoride Vol. V., p. 131.

Manganese Methods, Vol. VI., p. 35.

Note on Iron-Ore Analysis, Vol. I., p. 137.

Separation of Nickel and Cobalt from Iron, Vol. VIII., p. 335.

Some Causes of Error in Blank Analyses, Vol. IX., p. 81.

ABSTRACTS.

[ANALYTICAL CHEMISTRY, BY E. WALLER.]

Impurities in Potassium Sulphocyanate. Hendrick (*Chem. News*, lxiii., 130), found a sample of this reagent which contained 60.44 per cent. KCl and 31.01 KCyS. On evaporating and crystallizing out a solution of the material, cubical crystals were obtained. It was noted that in presence of much alkaline chloride, KCyS itself will crystallize in cubes.

Separation of Barium, Strontium and Calcium. Russman (*Fres. Zeits. Anal. Chem.*, xxix., 447), gives the result of experiments on different methods.

Frerick's chromate separation of Ba. Neutral K_2CrO_4 gave a precipitate always retaining some K_2CrO_4 . In presence of acetic acid and $NH_4C_2H_3O_2$, Ba could be readily separated from Ca, also from Sr in dilute solutions, provided the ratio of Ba to Sr was about 50 Ba to 10 or 15 Sr. With larger proportions of Sr it was unsatisfactory. $BaCrO_4$ could not be determined by ignition. Dissolving the $BaCrO_4$ in HCl, adding KI and titrating I, gave unsatisfactory results. The best results were obtained when very dilute HCl was used, and the titration was immediately performed.

Diehl's method. Dissolving $CaSO_4$ by $Na_2S_2O_3$ from the mixture of freshly precipitated $CaSO_4$ and $BaSO_4$. No accurate separation obtained.

H_2SO_4 separation of Ba from Ca. When one of these elements predominated largely (Ba : Ca = 100 : 1, or nearly the reverse), the separation was successful. Where 10 to 20 c.c. of HCl (containing 25.28 per cent.) were used, the $BaSO_4$ contained No Ca.

Sidersky's method. Separating Ca and Sr by boiling with $(NH_4)_2SO_4$ and $(NH_4)_2C_2O_4$, and then dissolving out CaC_2O_4 by dilute HCl. Unsatisfactory. When 8.4 per cent. HCl are present in the solution, an approximate separation can be effected. For separation of Ba from Ca, the method will serve.

Bloxam's method by arsenate (*Chem. News*, liv., 16 and 168). Suitable for qualitative purposes only.

Fleischer's method. Dissolving precipitated carbonates in standard HCl, titrating back excess of acid, precipitating $BaCrO_4$ by excess of standard K_2CrO_4 and determining excess of K_2CrO_4 by titration with $FeSO_4$. Results for Ba were unsatisfactory. Some Sr was always precipitated with the $BaCrO_4$.

The separation by digestion of $BaSO_4$ and $CaSO_4$, with a solution containing 3 parts K_2SO_4 and 1 part K_2CO_3 , filtering, drying and weighing $BaSO_4 + CaCO_3$, and determining the $CaCO_3$ alkalimetrically, gave good results.

Leison's oxalate method. Conversion to oxalate. Solution in H_2SO_4 and titration with permanganate. Sr and Ca can be determined by this means, but BaC_2O_4 is not completely decomposed by H_2SO_4 , and gave unsatisfactory results.

Iron and aluminum in phosphates. Glaser's method (*vide* QUARTERLY, xi., 273).

Von Gruber (*Fres. Zts.*, xxx., 9) finds this the most satisfactory and exact method yet devised. Meyer (*Chem. Zeit.*, 1890, No. 102), finds that when managed as described by Glaser, some Mg. compound will accompany the precipitate if that element is present. Test analyses on commercial phosphates showed results from about 0.1 to 0.4 per cent. too high when Mg. was present. Jones (*Zts. Angew. Chem.*, No. 1, 1891), proposes a modification, which provides for the presence of MgO and avoids the use of unnecessarily large quantities of reagents. His process is: Dissolve 10 grammes of the phosphate in aqua regia; dilute to 500 c.c.; of this take 50 c.c., evaporate to 25 c.c.; add 10 c.c. H_2SO_4 (1:5), then 150 c.c. of alcohol, mix and allow it to stand three hours; filter off the CaSO_4 and wash with alcohol. The washing is complete, when 10 drops of the filtrate with 10 drops of water fails to affect the methyl orange indicator. Distil off the alcohol; to the residue add ammonia, and boil until there is no odor of NH_3 . Wash the precipitate of iron and alumina phosphates three or four times with boiling water. If the washings run turbid, add a small amount of NH_4NO_3 to the wash water. Dry, ignite and weigh, or dissolve in HNO_3 precipitate with molybdate, and in the filtrate, separate the hydrates by warming with slight excess of ammonia.

Aluminum in Iron and Steel. Carnot (*Bull. Soc. Chim.* [3] v. 139) describes a method which he has used for several years, which differs but little from that of Stead (QUARTERLY, xi., 273), or Phillips (*ib.*, xii., 61). Dissolve 10 grammes in HCl, filter into a flask, wash the residue well, neutralize with ammonia and Na_2CO_3 and add a little $\text{Na}_2\text{S}_2\text{O}_4$. When the color has passed through violet to colorless, add 2 or 3 c.c. of saturated solution of Na_2HPO_4 and 5 or 6 grammes $\text{NaC}_2\text{H}_3\text{O}_2$. Boil until there is no odor of SO_2 . Filter and wash. Dissolve the precipitate with HCl, evaporate to dryness to separate SiO_2 . Take up with HCl, filter and treat the solution as before, using about 2 grammes $\text{Na}_2\text{S}_2\text{O}_4$, and 2 grammes $\text{NaC}_2\text{H}_3\text{O}_2$. Weigh the last precipitate $\text{Al}_2(\text{PO}_4)_3$ and calculate.

Commercial Aluminum. Regelberger (*Zts. Angew. Chem.*, No. 1, 1891) finds that the determination of Al by methods based on the proportion of H evolved by dissolving in KOH, gives incorrect results. The methods by determining impurities present he regards as better. For a direct determination 2 gms. of the sample are dissolved by the acid of 15 gms. pure KOH, in a platinum dish, and the solution made up to 200 c.c. In 50 c.c. $\text{Al}(\text{OH})_3$ is precipitated by boiling with a slight excess of NH_4NO_3 . The precipitate should be tested for SiO_2 after ignition. The impurities in the KOH used must also be allowed for.

Estimating Titanium Colorimetrically. Noyes (*Jour. Anal. Chem.*, v., 39). Mix 0.1 gm. of the finely powdered mineral with 0.2 gm. powdered NaF. Add 3 gms. sodium pyrosulphate. Fuse carefully, holding the burner in the hand, until copious fumes escape (2 or 3 minutes). Cool, dissolve in 15 or 20 c.c. cold water; filter, add 1 c.c. H_2O_2 solution, and a few c.c. dilute H_2SO_4 , and make colorimetric test, comparing with solution of known amounts of TiO_2 . The iron present affects the shade, hence the color of the standard solution should be made the same as that of the ore, by adding iron ammonia alum solution, before H_2O_2 is added to either. Experiments showed that under the conditions mentioned no appreciable amounts of TiF_4 were volatilized.

Determining Zinc as Phosphate. Stone (*Journ. Anal. Chem.*, v., 67) has investigated the influence of ammonia salts, the question having been suggested by the paper of Boyd (QUARTERLY, xi., 355). A 10 per cent. solution of microcosmic salt was used, 1 c.c. for every 0.01 gm. Zn present (about three times the theoretical amount). With this proportion, no material amount of the zinc failed to precipitate in the presence of ammonium chloride, sulphate or nitrate. With the acetate, especially in hot solution, there was some loss, and less than that proportion of the precipitant in presence of NH_4Cl also showed some loss.

Zinc in Ferruginous Ores. Platz (*Stahl und Eisen*, ix., 494) takes advantage of the insolubility of ZnS in acid, as compared with that of FeS , to effect the separation of Zn, without previously removing the Fe. 5 gms. of ore are dissolved in conc. HCl , 2 to 3 c.c. HNO_3 added, the mixture evaporated to dryness, diluted to about 200 c.c. and filtered, heated to between 80° and 100°C ., acidified, and H_2S passed to separate Cu, etc. After filtering, while the solution is still saturated with H_2S , acetic acid and $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$ are added, and ammonia is run in from a burette, the delivery tip of which is immersed in the solution. The solution is kept agitated, and the addition of ammonia (which must be gradual toward the last) is continued until the precipitate becomes permanently gray from formation of FeS . Dilute HCl (1 : 50) is then slowly added, with stirring, until the precipitate becomes white, and then ammonia is run in in the same manner as before until the precipitate is light gray. On standing a short time the ZnS separates rapidly, when it should be filtered and washed with dilute acetic saturated with H_2S . The subsequent management of the precipitate needs no explanation.

Determining Manganese as Phosphate. McKenna (*Jour. Anal. Chem.*, v., 140) has experimented as to the comparative advantages of Gibbs' or Blair's method of precipitating; also as to precipitation in glass or platinum. Gibbs adds Na_2HPO_4 in excess, dissolves in HCl , boils, and then adds ammonia in excess. Blair adds HCl before adding the phosphate. One method was found to be as good as the other. The necessity for getting a *crystalline* precipitate was found to be imperative. Boiling in glass (for three minutes, at any rate) had no detrimental effect. In washing, hot water alone seemed to be as good if not better than dilute ammonia or NH_4NO_3 solution. When a small amount of iron was present there seemed to be a formation of a double salt of

Mn and Fe, soluble in ammonia when excess of alkaline phosphate is not present.

Volumetric for Manganese. Moore (*Chem. News*, lxiii., 66) gives a method, depending on the formation of the violet $\text{Mn}_2(\text{PO}_3)_6$, and subsequent titration with a reducing agent, as FeSO_4 . The substance is dissolved directly in syrupy phosphoric acid, or dissolved, evaporated to a few c.c., and syrupy phosphoric acid added. KClO_3 is then added and the mixture warmed, finally heating until no odor of Cl is perceptible. After cooling, the solution, which has a color resembling that of permanganate, is diluted to 100 c.c. and titrated with standard FeSO_4 to complete disappearance of color, or an excess of FeSO_4 is added, and the excess titrated back with permanganate. Cr only interferes with this process.

Volumetric for Cobalt. Von Reis and Wiggert (*Zts. Angew. Chem.*, 1890, 695). Under the conditions obtained for the Volhard method for Zn (solution neutralized by ZnO , and titrated by permanganate, etc.), cobalt may also be titrated, a precipitate containing Co_2O_3 being formed. Since, however, the black precipitate does not readily subside, it is best to add an excess of permanganate, filter, and determine the excess by a standard solution of some reducing agent, as FeSO_4 . Zn salts and H_2SO_4 interfere with the reaction. The value of the solution is determined empirically.

Electrolytic Assay of Copper. Croasdale (*Journ. Anal. Chem.*, v., 133) gives a résumé of the work done on this subject from Davy to the present time, to be supplemented by further work of his own. He notes that H_2S is unsuited for determining the end of the reaction when only a drop of the solution is tested; also that in all cases the deposit should be washed with cold water with the circuit closed.

Tellurium Estimation. Donath (*Zts. Angew. Chem.*, 1890, 214) proposes the precipitation in the elemental form by hyposulphurous acid (made by the action of SO_2 solution on Zn) in the cold HCl solution. Precipitation is complete in 15 minutes. The washed precipitate is oxidized to TeO_2 by strong HNO_3 and weighed.

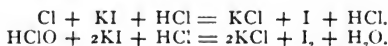
Volumetric for Tellurium. Brauner (*Proc. Lond. Chem. Soc.*, '90-'91, 31). The reaction of tellurites with iodine could not be used. TeO_2 could not be titrated with permanganate when in HCl solution. In H_2SO_4 solution, by a special method of manipulation, it could be done, but the result always showed 1 per cent. too high. By causing the reaction to take place in alkaline solution and then adding acid, results 0.35 per cent. too high were obtained. If these corrections are applied the results are accurate.

Carbon in Steel. Blair (*Jour. Anal. Chem.*, v., 121) and Shimer (*Ib.*, p. 129) report further experiments with the "Special Carbon Standard." The results obtained by Blair show further indications that the ammonium copper chloride introduces carbon, especially when acid is used in effecting solution. Pure CuCl_2 alone gave the same results whether

acid or neutral solution was used. Potassium copper chloride gave more satisfactory results than the ammonium compound. Modifications in the purifying train were found to be advisable. Shimer notes that filtering the carbon without suction seems better adapted to the removal of HCl from the separated carbon.

Carbon in Steel. Julian (*Jour. Anal. Chem.*, v., 162). On adding to the HNO_3 solution of steel (prepared as for colorimetric carbon test) some dilute permanganate solution, and digesting cold for some hours, hydrated MnO_2 separates in proportion to the amount of carbon dissolved. 36 parts C correspond to 220 parts Mn.

Hypochlorous Acid in Chlorine Water. Salzer (*Pharm. Zeit.*, xxxv., 457). The method of Lunge and Naeff is recommended. This depends upon the reactions—



The HCl remains free only when Cl is present. 25 c.c. of the water (neutral) to be tested receive the addition of 10 c.c. decinormal HCl and 1 gm. KI. After conversion of the free iodine to iodide by use of $\text{Na}_2\text{S}_2\text{O}_3$, an acidimetric titration is made. If the water contains no HClO, exactly 10 c.c. decinormal alkali will be required to neutralize.

The "Citrate" Method for Phosphoric Acid. Reitmaier (*Zts. Angew. Chem.*, 1890, 19 and 196) concludes, after an elaborate investigation, that in this method the precipitation of P_2O_5 is always incomplete; that variable amounts of Ca, Fe, Al or Mn always accompany the precipitate, affording sometimes a balance of errors. Ca and Mn are the chief contaminants. The quantity of Mg mixture must be proportioned to the amount of citrate used. The ignited precipitate always gives the reaction for orthophosphate (regarded as indicating the co-precipitation of a basic Mg salt). If HCl is used to dissolve the sample, much SiO_2 will appear in the precipitate. Even when H_2SO_4 is used, some SiO_2 appears in the precipitate, though, on the whole, the tendency in this case is toward too low results.

Nitric and Nitrous Acids in Spring Waters. Rosenfeld (*Fres., Zts. and Chem.*, xxix., 661). The reagent is 0.5 to 1 gramme pyrogalllic acid in 100 c.c. water.

To 3 c.c. of the water is added 6 c.c. of conc. H_2SO_4 and one drop of the reagent. The color developed may be compared with that produced in solutions of known strength, and thus made colorimetric. With less than 0.003 grammes N_2O_5 per litre, the color develops only after a time.

The reagent for nitrous acid is 0.5 gramme pyrogalllic acid in 90 c.c. water with 10 c.c. conc. H_2SO_4 . 100 c.c. of the water to be tested are mixed with 2 c.c. of the reagent. If 0.0004 gramme N_2O_5 per litre is present, a yellow color develops immediately, 0.0003 gramme in six minutes, 0.0002 gramme in twenty-three minutes, and 0.0001 gramme after about seven hours. The reaction can also be made comparatively colorimetric.

Oxygen Dissolved in Water. Linossier (*Bull. Soc. Chim.* [3] v. 63) effects this by mixing 50 c.c. of the water with 20 c.c. soda solution of 36° Be. and 20 c.c. of a 20 per cent. Rochelle salt solution, and titrates with standard FeSO_4 , using alcoholic solution of phenosafranine as indicator. A special form of apparatus is necessary to exclude the oxygen of the air.

Carbon Dioxide in Natural Waters. Leeds (*Jour. Am. Chem. Soc.*, xiii., 98), takes a measured amount of the water (500 c.c. in the case of soft waters) adds phenolphthalein (not too small an amount) and titrates with decinormal alkali. The number of c.c. used on 500 c.c. multiplied by 2.2 gives approximately the c.c. of CO_2 per litre. The results obtained agree well with those obtained by eudiometric analysis.

Hardness in Waters. Lepierre (*Bull. Soc. Chim.* [3] v. 299). The actual value of the French "degree" of hardness is 0.0103 and not 0.01 gramme CaCO_3 per litre, since it was established on a basis of 0.1 gramme soda soap per litre in the testing solution. The value of the different "degrees" in grammes CaCO_3 per litre is given as: French, 0.0103; English, 0.0143; German, 0.01785. The last is on the basis of 0.01 gramme CaO per litre.

The reagent used is 10 grammes dry (officinal) almond oil soap in 1 litre alcohol of 70° (Gay-Lussac). On each water four tests are made: 1st, total hardness; 2d, after precipitation by $(\text{NH}_4)_2\text{C}_2\text{O}_4$ (5 c.c. of a solution containing $\frac{1}{10}$ th of its weight to 100 c.c. water); 3d, hardness after boiling; 4th, after boiling and precipitating with oxalate. If the hardness runs over 35° the water must be diluted. In presence of Mg, if the first false latier is disregarded, and the addition of soap solution is continued, the flocculent precipitate of Mg soap gradually ceases to float, and an exact correspondence with Ca salts is obtained.

BOOK REVIEWS.

THE COLLIERY ENGINEER POCKET-BOOK. Revised edition, 12mo., 226 pp. and 194 pp. of tables. The Colliery Engineer Company, Scranton, Pa. 1891.

This convenient hand-book is a compilation of useful tables and short treatises on prospecting, mine management and engineering.

As its name indicates, it deals particularly with coal mining and allied subjects. Besides the usual tables of logarithms, areas, sines and cosines, squares, cubes and roots, etc., it contains tables of weights and measures, strength of materials, weights of iron, steel, etc., in different shapes, safe working loads for beams, pillars, ropes, etc.; also tables for the flow of air and water through pipes, and a table of corrections for stadia measurements.

The text deals with elementary mathematics, mechanics and engineering; then with mine prospecting, under which head is discussed the different coals, the opening of the mine, shaft and slope sinking, timbering, methods of work, etc.

Ventilation is thoroughly and carefully treated, the chemistry of gases, and methods of dealing with fire-damp, etc., being explained; also the exploration of mines after an explosion, and treatment of persons injured or asphyxiated. Hydraulics and hydrostatics are briefly but lucidly discussed, also the pneumatic system of power-transmission.

Mine surveying includes the description and use of the transit and wye level, and a discussion of the theory of stadia measurements, besides directions for field work.

Underground railways and mine machinery are adequately mentioned, the pumping, hauling and ventilating machinery all receiving due attention.

There are valuable hints regarding boilers and their management, also descriptions and illustrations of "faults," which are interesting and instructive.

The brief article on electrical mining machinery is an evidence that the book is well abreast of the times, and that others besides electrical engineers realize that electrical power transmission and distribution is at last taking its proper position as one of practical utility.

Finally there is a glossary of mining terms, and a table of useful memoranda, which the student in this branch of engineering will find especially valuable.

The book is well printed in clear type on good paper, and is of a very convenient size for carrying in the pocket.

The discussions and demonstrations in it are clear, and easily understood by any intelligent person. The student will find in it an epitome of what it is necessary for him to learn regarding the elementary principles of mining and mine management, and the engineer will find it a handy book of reference and a useful aid in field and office.

T. T. P. L.

THEORY AND PRACTICE OF SURVEYING. J. B. Johnson, C. E. 7th Revised and Enlarged Edition. Octavo. 730 pp. John Wiley & Sons. 1891.

In this latest revised edition of a popular text-book, the author has introduced new material which improves and strengthens the old, and brings the text up to date in descriptions of new instruments and methods.

In enumerating some of the new features, there may be noticed a new table of declinations, cuts and descriptions of the architect's compass-level, of Wood's double sextant in place of the goniograph, of the cross-section polar protractor, and of Porro's telescope. The latter instrument, called also the tacheometer, is a telescope for measuring distances by the telemeter, and does not require the application of the usual correction constant, for by the simple expedient of introducing an additional lens behind the object-glass, all measurements are made directly from the centre of the instrument. The most important of the new features are, however, the partial re-writing of the chapter on land surveying, and the description and explanation of the method of finding the true meridian by observations on Polaris at any time, with a table for reducing the observations.

In the chapter on land surveying, the author has incorporated much needed and valuable information relating to the laws governing surveys, especially those bearing on the retracing of old boundary lines and the re-locating of old monuments. This subject is one of importance, especially to the young surveyor, who, in the first few years of his experience, will probably be confronted with cases which will test his ability to decide disputes correctly and impartially. Depending, as he has to in his early experience, on the knowledge he has acquired while a student, it can easily be seen that the better the material he has had to study from, the better the decision he will make.

The author has supplied this material in a condensed and clear exposition of rules for interpreting descriptions of property and monuments as they should be interpreted.

Examples are given, also, showing how to describe and locate monuments so as to insure permanency and prevent confusion.

The description and explanation of the method for finding the true meridian by observations on Polaris at any time is a new and important feature, and with the appended table taken from the last Manual of Instruction of the Commissioner of the General Land Office, will prove of great assistance to the surveyor. The method of observation is the usual one, and the reduction of the observed data is not complicated nor long. Knowing the *local* time within five minutes will enable the observer to determine the meridian within one minute of arc.

In a new appendix are brought together descriptions of the geographical positions of the base lines and principal meridians governing the public surveys.

The other parts of the book, unchanged in this new edition, are practical, clear and well arranged.

The descriptions of the usual surveying instruments, their adjustments, etc., are probably not to be surpassed by any other text-book now in use. A more extended discussion of the methods of traversing, especially of the rapid method where the azimuths of courses are determined di-

rectly by backsighting, would be a welcome addition to the text; also descriptions of the application of paced distances and the ranging of lines by means of sight poles to the rough and hasty methods often used in filling in the detail of a topographical survey, would increase the usefulness of the book. A more extended discussion of the effects of local attraction, and their elimination from the bearings, would also seem an improvement to the text. With these two or three exceptions the book is one which will continue to retain its position in the front rank of practical scientific text-books, and, as a book of reference, will be found most useful by the engineer.

T. T. P. L.

THE METALLURGY OF SILVER, GOLD AND MERCURY IN THE UNITED STATES. By Thomas Egleston, L.L.D., Professor of Mineralogy and Metallurgy at the School of Mines, Columbia College, New York City. In two volumes. Vol. II. Gold and Mercury. 920 pp. Large octavo. John Wiley & Sons, New York. Engineering, London. \$7.50.

The first volume of Dr. Egleston's work appeared in 1887, and described in detail the various processes used in the metallurgy of silver in this country. The present work, Vol. II., is devoted to gold and mercury. The treatment of silver bearing copper and lead ores will be discussed in a separate volume forthcoming. Both this volume and the preceding one are the results of the personal investigation of Dr. Egleston during extended tours made in the years 1874, 1887, 1888 and 1889, supplemented by correspondence with his former pupils and others in direct charge of metallurgical establishments.

The plan of the work has been to present the general principles of the treatment, giving afterwards examples of the best practice under each one of the general heads.

The description of the methods of gold mining is arranged as follows, viz :

- | | | |
|-------------------------|---|---|
| <i>Shallow Placers.</i> | { | Gravel Mining,
Sluice Mining,
Beach Mining,
River or Bar Mining. |
| <i>Deep Placers :</i> | | |
| Hydraulic Mining. | { | Surface Mining,
Drift Mining. |
| <i>Vein Mining :</i> | | |
| Amalgamation. | { | Dry Crushing.
Wet Crushing. |

Concentration and Chlorination.

The treatment of the auriferous material by the primitive pan and cradle, the "Tom," arrastra and by modern hydraulic mining, is comprehensively described with the Professor's usual thoroughness of detail, and occupies the first four chapters of his work.

Chapter V. is devoted to the subject of gold stamping and amalgamating, and under the modern finely developed mill machinery are discussed crushers, Huntington mill, feeders, concentrators, amalgamators and the Knox pan; the discussion also including tail treatment, retorting, casting, losses of gold, etc. This chapter is of necessity voluminous, and occupies nearly two hundred pages amply illustrated by thirty-five engravings.

The extraction of gold by chlorine gas comprises Chap. VI., being described under the Plattner process with the Mears and Thies modifications.

Under parting processes (Chap. VII.) are described the nitric acid process as formerly carried on at the Philadelphia mint, the double acid process used at the mints of Philadelphia and San Francisco, the sulphuric acid process now used at the mints of New York, New Orleans, Carson City and Denver, and the Gützow or silver sulphate process formerly in vogue at the San Francisco mint. In addition are also given valuable and interesting tables on cost of parting by the different mints, legal weights of coins with limits of tolerance and abrasion, coinage production and consumption, etc.

Chapter VIII. is devoted to the treatment of mercury-ores in California, the processes being classified as follows, viz.: I. Distillation; II. Precipitation; and III. Roasting and Reduction in intermittent or continuous furnaces; closing with a complete table on the production and price of mercury from the individual California mines from the year 1850 to 1888 inclusive. The work is well illustrated and handsomely printed with clear type and generous marginal space. It is rendered easy of access by the thorough and carefully compiled index. J. S.

WEDDING'S BASIC BESSEMER PROCESS. Translated from the German by William B. Phillips, Ph.D., Professor of Chemistry and Metallurgy, University of Alabama, and Ernst Prochaska, Met. Eng. With Supplementary Chapter on Dephosphorization in the Basic Open-Hearth Furnace, pp 224. 8vo. Cloth. Scientific Publishing Co., 27 Park Place, New York, 1891.

The translators discuss the basic processes under the following heads: Chapter I.—*The earlier methods of dephosphorization* are described and commented upon.

Chap. II.—*The basic lining*, giving the history and description of the various patents taken out, the manufacture of tar bricks, etc.

Chap. III.—*Construction and lining of the Converter*, giving the various shapes in use.

Chap. IV.—*treats of the materials used*, the pig-iron, recarbonizers, flux and blast.

Chap. V.—*Details of practice*. Discusses duration of process, capacity of the converters, waste, arrangements for pouring, cranes, ingot treatment, soaking pits, etc.

Chap. VI.—*Chemical and physical reactions*, giving analyses of slags, iron, basic materials. Phenomena of oxidation, action of iron, silicon, manganese, carbon, phosphorus and sulphur; the influence of the basic fluxes, evolution of heat, etc.

Chap. VII.—*General arrangement of Basic Bessemer works*, giving numerous plans.

Chap. VIII.—*Utilization of the Basic Bessemer slag*, analyses, etc.

Chap. IX.—*Dephosphorization in the Open Hearth*. Materials used in furnace construction, mode of operation and analyses.

Chap. X.—*Economic results of the Basic process*, and list of basic plants in Europe and the United States.

Appendix.—*Desulphurization of pig-iron*, description of methods employed.

Dephosphorization in Basic Open-Hearth Furnace. By Ernst Prochaska. Gives construction of furnace in detail; numerous analyses of iron, slag, steel, basic refracting materials, etc., and the advantages claimed for the process. Under the general head of *Notes* are appended several pages of addenda, including a description of the basic open-hearth process as carried out at Pottstown, Pa.

This able work is illustrated by 70 engravings, special attention being called to Figs. 54 and 55 in the chapter on the chemical and physical reactions. These two figures are charts showing the behavior of all the ingredients of the pig-iron during the Bessemer process, and presenting the facts in a graphic form, which renders their significance and relations apparent at a single glance.

The material here presented in this work covers the essential knowledge requisite for a good understanding of the basic processes without going into minute detail, and as such will no doubt receive the hearty commendation of metallurgists, students and all interested in the manufacture of steel.

This work is printed on excellent paper, with clear type, and the illustrations are of good order. J. S.

Mr. Robert Grimshaw, General Editor of the Trades Department of Funk & Wagnall's Standard Dictionary, being desirous of making as complete as possible his list of mechanical and industrial terms, requests manufacturers of machinery and tools having important parts not found on those of other makers, or the names of which are not yet in general use, to send the name, definition and use of each such part to him at 115 Bible House, New York City.

ELEMENTS OF CRYSTALLOGRAPHY, FOR STUDENTS OF CHEMISTRY, PHYSICS AND MINERALOGY. By George H. Williams, Ph. D., Associate Professor in Johns Hopkins University. New York, Henry Holt & Co., 1890. 8vo. 250 pp.

The author makes no claim to completeness or originality, merely attempting to present geometrical crystallography clearly and concisely, with the amount of detail usually of service to students of the allied subjects, mineralogy, petrography, chemistry and physics.

The book begins with a brief chapter upon crystal structure; the general laws are explained and stated in the second chapter; the statements are long and not so easily fixed in the memory as more concise statements qualified where necessary by exceptions.

In discussing the different systems a duplex definition and classification is followed, dependent upon the closely related ideas of axes and of degrees of symmetry. While the former is essential to the description of the form and the determination of the symbol, the latter is not, and admittedly it is not especially simple. "A definition based entirely

upon symmetry cannot be wholly satisfactory, since it strictly excludes the hemihedral, tetartohedral and hemimorphic forms, whose grade of symmetry is always less than their corresponding holohedrons." Why not then, for a student's work, omit discussions as to principal and secondary planes and axes of symmetry, except in so far as needed in a discussion of the laws of symmetry. Very little is gained by knowing that the rhombic dodecahedron is disymmetric, the trigonal trisectahedron monosymmetric, the cube quadrisymmetric and the gyroid asymmetric.

The author wisely uses first the fundamental and easily understood symbols of Weiss, and later the condensations of Naumann, Dana and Miller.

In general the work is all that it claims to be; the definitions and explanations are very satisfactory. The discussions of that, to beginners, most confusing point, the fundamental form and its relations to the other forms, are very clear. Particularly satisfactory is this, "The axial ratios derived from all forms occurring on crystals of the same substance under the same conditions, must be rational multiples of each other, while those derived from forms on crystals of different substances are irrational multiples of each other. Thus the axial ratio becomes a physical constant for all crystallized matter that is not isometric, and serves to identify it in the same way that a specific gravity hardness, or elasticity does."

Interesting chapters are devoted to crystal aggregates and imperfections of crystals, and an appendix contains a brief explanation of zonal relations between crystal planes and their graphic representation by means of projections.

A. J. M.

BULLETIN OF ALUMNI AND COLLEGE NEWS.

In accordance with the recommendation of the University Council, the awards of fellowships in the academic year 1891-2 are as below. It is proper to call the attention of applicants from a distance to the fact that in the transition from an old order of fellowships to the new, practically only five of these twelve were this year available for outside appointments. Of these five, four have been awarded to men not graduates of Columbia College. Next year the number of fellowships open to outside competition will be materially larger, and after two years from this time larger still. The total number of fellowships for 1891-2 is twelve; for 1892-3, eighteen; and for 1893-4 and thereafter, twenty-four.

Awards for 1891-2.

George Clinton Densmore Odell, A.B., Columbia College, 1889; subject, English.

Frank Pierrepont Graves, A.B., Columbia College, 1890; subject, Greek.

Charles Harris Hayes, subject, German.

Harold Griffing, A.B., Columbia College, 1890; subject, History of Philosophy.

Charles Riborg Mann, A.B., Columbia College, 1890; subject, Physics.

Edwin Mortimer Blake, E.M., Columbia College, School of Mines, 1890; subject, Mathematics.

John Farr Putman, Columbia College, 1891; subject, Greek.

Edward Hymes, Columbia College, 1891; subject, Mathematics.

William Z. Ripley, B.S., Massachusetts Institute of Technology, 1890; subject, Political Economy.

C. A. Stuart, University of Toronto, 1891; subject, History.

Max Leopold Margolis, Leibnitz Gymnasium, Berlin, Columbia College; subject, Semitics

John C. McMynn, A.B., Williams College, 1890; subject, Physics.

LECTURES TO BE GIVEN AT COLUMBIA COLLEGE BY E. C. STEDMAN.

Title of the course: "The Nature and Elements of Poetry."

I. *Oracles, Old and New.* (Introductory and historical, with considerations on Poetry and Science).

II. *What is Poetry?*

III. *Creative Poetry, and the Poetry of Self-Expression.*

IV. *Meiancholia.* (The preceding topic continued, with special regard to modern times).

V. *Beauty.*

VI. *Truth.*

VII. *Imagination.*

VIII. *The Faculty Divine.* (Discussing Passion, Inspiration, Genius, Faith).

DEPARTMENT OF ARCHITECTURE.

The Faculty of the School of Mines, at their last meeting, approved of certain important changes in the Course in Architecture. In the first year, in place of Graphics, two hours a week and two afternoons are to be given to Projections and Shades and Shadows, and the three hours a week hitherto given to Descriptive Geometry and Botany are to be given to the lectures, recitations and drawing exercises in Ancient Architectural History now taken in the second year. The Elements of Architecture are also begun, and Design from Dictation. In fact a chief part of the professional work now done in the second year will be done in the first. In like manner the History now taught in the third and fourth years will be given in the second and third. This will leave the fourth year free for serious professional work. To this end additional work in History and Design is provided in that year, with Descriptive Geometry of an advanced character, and Stereotomy.

As this offers more studies in the fourth year than any single student can profitably pursue, it was voted that each student, with the advice and consent of the head of the Department, shall make a selection among them, "such elective courses to be the equivalents in value and difficulty of the course hitherto established." It is proposed presently to add also advanced work in Engineering Design and Practice. It will then be practicable for a student, having at the end of his third year got through with all his elementary and preparatory studies, to devote his last year either to History and Design or to Construction and Practice, as he may prefer.

At the same time the University Faculty of Mathematics and Applied Science established University Courses in Architectural History and Architectural Design, in preparation for the degree of Master of Arts. There will presently be added corresponding courses in Construction and Practice. It will then be practicable for men who elect Design in their fourth year to take another year, either at once, or after a period of office-study, for the study of Construction and Practice, and for those who have elected these branches before graduating to take an extra course of History and Design. This last course is indeed open at once, to all graduates of the Department, and there is reason to believe that quite a number of men, who are ready for another year of serious study, but have not the time or money for serious study abroad, will presently avail themselves of these opportunities.

Such students, added to the men in the fourth year, would give us classes, whether in Design or in Construction, well prepared to profit by all the resources at our command, and with leisure to give to their work the uninterrupted time and attention that advanced work requires. The Department is prepared to give much more thorough and pertinent instruction than has hitherto been given, but hitherto no students have had time to take it. The men have left the school just as they were ready to receive the best things it had to give.

In preparation for these changes, and for covering as much ground as possible in the first three years, the work in Projections, Shades and Shadows and the Elements of Architecture has been simplified and consolidated, so that each of these branches illustrates and is illustrated by the other. At the same time an exercise has been introduced into the first and second years which serves not only to stimulate the creative imagination of the students but to impart some elementary notions of water colors, perspective, construction and architectural planning and composition. This is a weekly exercise in Design by Dictation, in which some building is described, more or less in detail, sketched by the class at the time, and then drawn in plan, elevation, section and in perspective, and rendered in color and india ink. These drawings are made on so small a scale that they do not require any previous knowledge of architectural detail, being in fact exercises in planning and in the composition of masses.

The same system has been applied with equally satisfactory results to the study of ornament, the *motif*, or general arrangement of a Renaissance pilaster capital, for instance, being described, and each student left to develop the idea according to his own taste and judgment.

The Study of Modelling, which was laid aside some years ago after a brief trial, for lack of a suitable room for the work, has now been resumed, a material having been found quite as manageable as clay, but which does not dry and so makes no dirt. The work can accordingly be done without inconvenience at the student's drawing-tables.

At the May meeting the Trustees promoted Mr. Sherman to be an Adjunct-Professor in Architecture and Mr. Harrinan to be Instructor in Architectural Drawing, and reappointed Mr. Snelling as Tutor in Architecture and Mr. Kress as Curator of the Architectural Collections.

The McKim Fellowships in Architecture, for which the first competition has recently taken place, have been awarded to Messrs. A. C. Muñoz, '88, and A. M. Welch, '90. Honorable mentions in design were also awarded to Messrs. J. M. Hewlett, '90, and R. K. Mosley, '89; and in construction to Messrs. R. D. Kohn, '90, and H. E. Donnell, '87. The Committee of Award was the same that served last year as jury for the Columbia Fellowship, consisting of Messrs. R. M. Hunt, C. F. McKim (the founder of the Fellowships) and Thomas Hastings, Jr., of New York, and Mr. Arthur Rotch, of Boston. The marks in Design, as judged by the committee, and those in Construction and Office-practice, in which the papers were marked by officers of the School of Mines, were assigned equal value in determining the final result. The committee note a gratifying advance in the quality of the work submitted by the sixteen competitors, as compared with that handed in for the Columbia Fellowship last year, both in design and rendering. The two Fellowships are of \$1000 each, and are to be spent in foreign study and travel, according to programmes to be submitted by the winners for approval by the President and by the Professor of Architecture.

The second class have begun drawing from the architectural casts in the Metropolitan Museum, and will continue these exercises upon the re-opening of the Museum early in May.

A. D. F. H.

DEPARTMENT OF MINERALOGY AND METALLURGY.

During the year there have been added to the mineralogical collection fifty-eight new species and twenty-five new varieties. The collection has been recounted and catalogued showing now, independent of the special student, conference and determinative collections which include about 8000 specimens; a total of 19,745 specimens, representing 955 species. It is interesting to note the following: Between 1879 and 1886, only 75 missing species were obtained, or say 11 per year. In 1887 the working force of the department was increased, making collection work possible, and in the succeeding four years, 297 new species were secured, or an average of 74 per year.

The department has received from Olcott, of '74, Iles, of '75, Rolker, of '75, Chazal, of '81, and Rowland, of '84, a fine rock section cutter, which was used at once by a number of persons desirous of learning this branch of mineralogy.

From Terhune, '70, Noyes, '75, Lægget, '79, Ruttman, '80, Hopke, '80, Morgan, '84, and Perkins, of '88, 288 rock sections which are in use in the department.

Lindsley, '70, Gratacap, '76, Mackintosh, '77, Hollick, '79, Koch, '79, Klepeiko, '80, Parsons, '82, Young, '82, Payne, '82, Bullman, '83, Channing, '83, Davis, '87, Church, '87, Müller, '87, Lusk, '87, Taylor, '87, have presented a large and very fine Wollaston's goniometer. Mr. R. Pearce, a set of gold crystals from New Mexico.

ASSOCIATION OF THE ALUMNI.

The Secretary takes great pleasure in announcing that in response to his circular of request, there have been nearly 250 sets of professional service sheets sent in by Alumni, and the new scheme has attracted several who were not before members, to join the Association. Preferring not to issue a list until more than fifty per cent. of the Alumni have responded with data for publication, the new list will not be contained in this issue of the *QUARTERLY*, and those who have not replied to the circular request, are strongly urged to do so and as soon as possible, to the end that the list may be prepared for the final number. The plan outlined seems to have been approved, and Alumni are requested to do all in their power to further the idea. A bulletin of vacancies and available is issued in connection herewith on the following page.

F. R. H.

Secretary.

EMPLOYMENT BULLETIN.

The Secretary has the following memoranda as to places vacant, and Alumni available for employment. The whole numbers belong to avail-ables; the decimals refer to vacancies. Inquire by making use of the list number.

No. 1. M. E. '86. Mining experience in Montana; engineer with experience in wire-rope engineering.

No. 2. Ph. B. Chem. '79. Instructor in chemistry and in field.

No. 3. M. E. '90. Mining in Tennessee.

No. 4. M. E. '80. In structural engineering and insurance inspection.

No. 5. Ph. B. '82 and Ph. D. Professor of chemistry, geology, etc., at West; prefers similar chair at East.

No. 6. Ph. B. Chem. '89. In charge of chemical manufacturing department, prefers outside superintendency of similar work.

No. .01. Assistant chemist in commercial laboratory in New York.

No. .02. Assayer, for wet and dry methods about a smelter, in Texas. Salary, \$75 to \$100.

No. .03. Mine superintendent and captain with experience in gold and some as manager; must assay and explore; salary begins at \$100.

No. .04. Chemist and mineralogist, to take charge of laboratory of a copper company in Canada; salary, \$1000 to \$1200.

No. .05. Teacher of Applied Mathematics, surveying, strength of materials, descriptive geometry, etc., as assistant to chief in an Indiana college; civil engineer preferred.

THE SCHOOL OF MINES QUARTERLY.

VOL. XII.

JULY, 1891.

No. 4

BRICK PAVEMENTS.

BY WERNER BOECKLIN, JR., C.E.

BRICK PAVEMENTS, although by no means a modern invention or of American origin, have of late years been steadily growing in favor in this country, especially in many of our Western cities. Capital has been attracted to the subject, and to-day many kilns are in operation to the utmost of their respective capacities. The growing popularity of the brick pavement is not only justified by our own experience, accumulated within the last twenty years, but also by lessons we are now learning from others, though we might have learned them years ago. In Hague, Rotterdam, and other large cities of Holland, brick has for more than a century been the only finished material used for paving. The streets of the principal cities of Holland are subjected to as heavy a traffic as the streets of any of the other large cities of Europe. In Hungary, too, brick pavements, laid in cement, are very common.

As a matter of course our pioneers in this system of paving were not at first altogether successful. The nature and quality of the clay best suited for the purpose had to be ascertained, the best way of burning the brick, and the most practical way of laying had all to be determined. But time and all those accumulated experiences enable us to-day to handle the subject with almost mathematical accuracy. Such a variety of conditions have to be considered,

however, in order to arrive at a strictly perfect and satisfactory brick pavement, and so much has been written within the last two or three years in reference to the various technical facts and theoretical points of the system, that the present writer has been tempted to here state and elucidate those facts and points, together with additional data bearing thereon, as gathered by himself in the course of some practical investigations; for it is becoming more and more evident that brick will supersede all other pavements—is destined to be the pavement of the future.

CLAYS.

Clays, to make good pavers, should be able to stand a high temperature in the kiln; they should not be entirely infusible, but should contain fluxing agents in such proportions as to render the brick tenacious and to give to it a slight degree of vitrification. The occurrence of limestone in the clay is particularly to be avoided as it is changed to caustic lime in the burning, and by the action of moisture will slack and thus disintegrate the brick. Iron will not be found injurious in a paving brick. The amount is practically limited, however, when it comes to exposing the brick to a high degree of heat; 6 per cent. of iron will render the brick useless.

The elasticity of brick is due to the aluminum contained in the clay and not to the iron.

At the convention of the National Brick Manufacturers, held in Indianapolis, February, 1891, Mr. Jones said, in this connection: "The majority of good building brick clays, with different treatment, will make fairly good paving brick for light travel. But to stand the wear and traffic of large cities, and to equal granite and other high-priced pavements, there must be a careful selection of clays, such as semi-fire clays or some of the shale clays, that will stand a high degree of heat, so as to become thoroughly vitrified and at the same time have that toughness that is necessary to stand the continuous friction of heavily-loaded teams from and to the freight stations and boat wharves."

Mr. C. P. Chase gives as the average composition of clays used for paving brick: 69.1 per cent. silica, 15.5 per cent. alumina, 5 per cent. of chemically combined water, 2 per cent. moisture, 2.5 per cent. iron, 2.5 per cent. magnesia, 3 per cent. lime. These results he derives from analyses of ten of our best brick.

PREPARATION OF CLAYS.

Formerly it was the practice to weather the clay after it was taken out of the bank ; that is, to pile the clay in heaps and allow it to stand through the winter. Alfred Crossley says in this connection : " Clay is always improved by weathering, no matter how good it is naturally. Common brick made from weathered clay are stronger, sounder and less liable to flaws and cracks than those made direct from the bank." But in this age of haste this is too slow a method by far, and so a long line of fine machines has been placed upon the market to do as nearly as possible what was formerly left to nature. Upon the continent of Europe, weathering is still resorted to quite extensively, but in the United States it has been replaced almost exclusively by the action of machinery.

Clays for pavers must not be prepared as are those for common brick, but must be well tempered and mixed. Neither are all clays to be treated alike in this respect. Bricks are divided into three classes, namely :

1. Soft mud.
2. Stiff mud.
3. Dry pressed.

Either 1 or 2 will answer for making pavers, 2 being preferable, while 3 will not answer at all. As every clay will not work into a stiff mud some will have to be treated by mixing so as to make this possible. The stiff mud being denser and stronger than the other, it is found to answer our purpose much better. This strength or toughness sought in a paving brick is due in a great measure to the fineness of the particles of clay ; the finer we crush the clay the better will be the results, for fine clay will vitrify much more quickly than a coarse one and will stand abrasion better.

The method used in handling the clay at Burlington, Iowa, is as follows: The clay is excavated by hand and placed in cars holding about one cubic yard. These are hoisted on an inclined track and their contents dumped into a hopper which feeds into the dry pan. Here the clay is crushed by means of heavy revolving rollers to about the size of small bird shot, when it drops through the perforated bottom of the pan into buckets on an endless belt. This carries it to the tempering machine where a man stands with a hose in hand to thoroughly wet the clay. The stream is just sufficient to make the clay into a very stiff mud. It

is now ready to pass into the brick machine, from which it comes out in long bars and is cut off the required length.

BURNING.

"Clay is silicate of alumina with foreign admixtures of sand, iron, lime, magnesia and alkalis. Under the action of heat the alkalis melt and begin to dissolve the other materials. Increase the heat and this action becomes rapid and more complete; at the same time the iron, lime and magnesia begin to act as fluxes. Continue to increase the temperature and we continue the solvent action. When all the particles have become impregnated with the melted portions we have reached vitrification. This solvent action is then a chemical one. The alkalis, alkaline earths, sand and alumina combine to form double silicates. These silicates—slags let us call them—when cooled, form an insoluble matrix in which are imbedded and firmly cemented the undissolved particles of clay."*

A good bond must then be given to the material making up the brick, to insure which a certain temperature, which must be uniform, is employed. It is difficult to obtain this uniform temperature, but it should be had as nearly so as possible, by using care in the firing so that most of the bricks will reach a good bond at about the same time. It is, therefore, necessary to retard this bonding action in the hotter parts of the kiln and to increase it in the cooler parts. To do this it is necessary to increase the surface exposed to action of heat in the hot parts by massing the bricks closer together.

That this stage of the manufacture of paving bricks is of great importance may soon be learned by a close observation of the manner in which the bricks wear when put into the street. If some of the bricks begin to crumble and give to the street a general appearance of roughness you may know that the "burn" was not uniform.

"If blocks are made 4 inches by 8 inches they should be set in kiln at least an inch apart and the water-smoking should be slow and steady." . . . "The kiln should not be opened until nearly cool. As a rule, it takes as long to cool off a kiln, to get the best results, as it does to burn it."

"A good paving brick is burned slowly and made as hot as it

* Ellis Lovejoy, in *Clay Worker*.

will stand without fusing, then covered so tight that no draft of air will pass through the kiln. It must cool off by the natural radiation of heat from the centre to the surface.

The moment cold air strikes a hot brick, the tenacity and strength of that brick is weakened, and abrasion by contact or friction of heavy bodies passing over it is much increased. This is why I insist upon the great importance of using fine damp clay to lute over or cover a kiln as fast as well-burned places on top appear; it not only saves labor and fuel, but gives uniform hardness and tenacity to the brick." *

The usual fuel for burning the bricks is bituminous coal, although oil has been tried as well as gas. D. V. Purington tried using crude oil at his kilns near Blue Island, Ill. Oil was also applied by P. L. Sword & Son, of Cleveland, Ohio. The saving over coal is estimated by Mr. Purington to be fully 33.5 per cent. Although this was not for paving brick, the writer thinks that oil could be used for burning pavers with success.

Since writing the above, Mr. Purington has experimented with petroleum and steam at Galesburg, and the process shows such evident merits that the Granite Brick Company of Burlington, Iowa, put the method to practical test at the works in that city.

The manager of the works at Burlington, Mr. Neis, has kindly given the writer some information with regard to the burning of crude petroleum. Soft coal had been used, and the experiment of using petroleum was tried. Slight changes only had to be made about the furnaces. The crude oil was delivered by gravity to the combustion-chamber, into which it was sprayed by means of a jet of superheated steam. It was expected that all smoke would be avoided by this process, and that the temperature could be raised to any desired degree in a very few minutes, and a kiln of brick be burned by this in about half the time required when using coal, and that the burn would be more uniform.

The experiment was not a success, and the use of oil had to be given up at Burlington on account of the high density of the clay found there. The heat derived from the use of oil was intense, but was not carried through the kiln, and did not therefore give such uniform results as the heat derived from coal. We see from this that while oil might be used in burning a light clay, it has not yet proved a success with dense clay.

* J. W. Crary, Sr., in *Clay Worker*.

An up-draft kiln cannot be employed in the burning of paving brick, as it gives non-uniform results. With the down-draft kiln from 75 to 90 per cent. of the bricks are fit for pavers, the rest being good as common building brick, or to be used as the bottom course in the street. The best paving brick will come from the middle third of the kiln, the upper and lower thirds being somewhat inferior in quality, although they can be used and are used in the street. The color of different varieties of brick is no indication of their strength.

LAYING.

There are three essentially different methods of constructing a brick pavement. The first and most common way is that of a layer of bricks laid flat, and the paving bricks proper placed on top of this layer on edge. The second consists of only one layer of bricks set on their two-inch side. This method is not so generally used as the first. The third construction is the same as the first, except that boards are laid in place of the lower course of brick, and the pavers placed on top of these. This is a patent pavement, and has but a comparatively limited use. Reference is made here only to those bricks of the ordinary form. There is another method employed which involves the use of a patent paving block; only the one layer of bricks is used in this case.

To describe the first method, it will answer all purposes to take an actual case which the writer investigated thoroughly, and which is representative of good practice followed in many of our western towns.

The system employed in Burlington, Iowa, is as follows: On those streets which were originally macadamized, the road is simply torn up to the required depth, and, in case of this not carrying the sub-grade beyond the macadam, three inches of sand are spread over and brought to the proper form by means of a drag extending from curbstone to centre of street. When all the macadam has been excavated, and sub-grade is on the earth road or where there was no macadam originally, a foundation of about two inches of cinders is spread and well packed by a 2000-pound roller, and on this is placed a layer of sand two inches thick, evened over as in the former case. The cinders are found to answer the purpose of sub-foundation admirably, as they pack solidly and are cheap, costing but ten cents per wagon load. Upon this layer of sand or

cinders, a course of common bricks is laid, the bricks being set flat and lengthwise of the street, care being taken to break joints. The course is then thoroughly rolled or rammed to settle into position. Upon this is spread clean river sand, which is swept well into the joints, sufficient being left to cover the course to the depth of two inches.

Everything is now ready for placing the paving brick proper, which are laid on edge and crosswise of the street, breaking joints as in the other layer. After rolling well with a hand-roller, enough sand is spread over the top to fill the joints and cover the entire course to a depth of about one inch. This sand is allowed to remain to be carried into the joints as much as possible by means of traffic and rain. At street intersections the top and bottom courses are laid at an angle of 45 degrees with the street line, and at right angles with each other.

On grades from 0.5 to 4.0 per cent. the street should be crowned about 0.6 of a foot for a width of 48 feet; on grades greater than 4.0 per cent., the crown can be made 0.4 of a foot in 48 feet width, or even less.

In Duluth, both brick and stone are recommended for grades up to and exceeding 10 per cent. For purposes of comparison,—especially of cost,—the suggestions for each are given herewith.

BRICK.

On grades up to 6 per cent.:

Best paving brick laid on concrete, probable cost per yard, \$2.25 to \$2.75.

On grades exceeding 6 per cent.:

Best paving brick of special form . . . laid on a concrete foundation, probable cost per yard, \$2.50 to \$3.00.

On grades exceeding 10 per cent.:

The same form as that for grades exceeding 6 per cent. is suggested.

STONE.

On grades of 10 per cent. or less:

Rectangular stone blocks of the usual size and pattern, with sand joints, to be laid on a foundation of concrete or broken stone, probable cost per square yard, \$2.75 to \$3.25.

On grades exceeding 10 per cent. :

(1.) Rectangular stone blocks, ranging from $3\frac{1}{2}$ to 4 inches in width, and chamfered on the upper edges. . . . The chamfering is needed to afford a safe foothold essential for horses to overcome very steep grades. Probable cost per yard, if laid on a stone foundation, \$2.75 to \$3.25. And when laid on concrete, \$3.00 to \$3.50.

(2.) Kidney or cobblestone selected of nearly equal sizes, not exceeding three inches in thickness, laid on a concrete foundation and set in cement mortar. Probable cost per yard, \$2.00 to \$2.50.

FOUNDATIONS.

The foundation is of the first importance to a pavement, for upon it depends entirely the future stability of the roadway. In localities where the soil is of such a nature as to furnish a good substantial foundation, the first layer of brick may not be found necessary, but, as a general rule, this course cannot be dispensed with, and will insure to the pavement a longer life than if it were left out.

A clay soil is not fit for a sub-roadway, owing to the fact that it retains water so easily. A foundation in such a case, therefore, must be of some material that will allow water to run off to sides of road, where it can be collected in drain tile and led to proper channels.

Well-rolled macadam, upon which is spread a layer of sand or cinders, will be found to answer as a foundation in many cases; as, for instance, where the grade of the street is to be raised.

Concrete is sometimes used for foundation material, but this is mostly in the large cities where the traffic is heavy, it being scarcely advisable in places under 25,000 or 30,000 inhabitants on account of the increased cost.

Some authorities advise the filling of joints with hot coal-tar cement, claiming that this prevents the water from getting to the foundation, and thus causing the pavement to settle in spots, finally destroying it completely. And, again, others claim that, for the reason that the tar will *not* allow water to go through, its use is therefore to be avoided. Tar is used to a very limited extent. If a good foundation is secured, and ample means of conveying both surface and sub-roadway water away, coal-tar or its equivalent becomes an unnecessary expense.

Boards previously immersed in coal tar are used as a founda-

tion in the Hale pavement. This method is said to give good results, although it will never be universally employed. A very great disadvantage of the board method is brought out when it becomes necessary to tear up a strip of the street for pipe laying, the boards must be sawed off and after the bricks are relayed the pavement is never apt to be as uniform as when first put down.

WEAR OF PAVING BRICK.

The tests usually made with brick are; 1. Crushing strength. 2. Resistance to abrasion and impact. 3. Absorptive power.

Crushing Strength.—As a matter of fact the crushing strength of brick is not of much practical value in their selection for paving purposes, for the reason that all the bricks made for this use will stand any direct compression brought upon them by the passage of loads. This will be seen to be the case when it is remembered that a good working strength for a paver is 8000 pounds, whereas the load per inch of tire is about 700 pounds.

Resistance to Abrasion.—This test is made by putting the bricks, with pieces of iron, into a horizontal revolving cylinder. Although this does not represent the actual conditions in the street, still the tests gives some sort of an idea of what a brick is able to stand. Professor Baker points out in his book on brick pavements that the loss due to abrasion decreases as the edges of the bricks become rounded off, and that hence the results obtained during the first half hour are of least value.

To determine the relation between wear and tonnage, the writer herewith quotes at some length from Professor Baker's book before mentioned, using also additional data furnished him by W. P. Butler, City Engineer of Bloomington. The matter given herewith is from experimental tests made in St. Louis in 1873. An official test made in the same year did not prove a success, due to the fact that the bricks were as stated by the maker, an experimental lot incorrectly made and burned, for which reason he objected at the time to having any test made.

I. "The manufacturer of the above brick had others made of smaller size and under more favorable circumstances, which were non-officially tested with the same apparatus, at the same place, under exactly the same conditions as the official tests above. Thirty-five 'hydraulic pressed brick' were placed under one wheel, and thirty-one 'hand-made pressed brick' under the other. The cart

*Relative Resistance of Brick and Stone to Abrasion.**

Ref.No.	WEAR OF THE BRICK IN TERMS OF THAT OF							
	Granite from					Columbia Marble.	Berea Sandstone.	Indiana Limestone.
	Quincy.	Aberdeen.	Martindale.	Berlin.	Iron Mt.			
1	2.0	2.7	2.7	2.7	2.0	0.3	0.1	0.2
2	6.5	8.7	8.7	8.7	6.5	0.9	0.5	0.5
3	1.8	2.3	2.3	2.3	1.8	0.2	0.1	0.1
4	5.0	6.7	6.7	6.7	5.0	0.7	0.4	0.4
5	6.2	8.3	8.3	8.3	6.2	0.9	0.5	0.5
6	1.0	1.3	1.3	1.3	1.0	0.1	0.1	0.1
7	7.5	10.0	10.0	10.0	7.5	1.0	0.6	0.6
8	3.2	4.3	4.3	4.3	3.2	0.4	0.2	0.3
9	4.8	6.3	6.3	6.3	4.8	0.7	0.4	0.4
10	9.2	12.3	12.3	12.3	9.2	1.3	0.7	0.8
11								
12	3.0	4.0	4.0	4.0	3.0	0.4	0.2	0.2
13	3.0	4.0	4.0	4.0	3.0	0.4	0.2	0.2
14	1.2	1.7	1.7	1.7	1.2	0.2	0.1	0.1
15	2.5	3.3	3.3	3.3	2.5	0.3	0.2	0.2

was then moved back and forth, in the same track, until 146,000 transits had been recorded. This was a tonnage of 146,000 tons on 2½ inches, which is equivalent to 700,800 tons per foot of width—a tonnage equal to thirty-five years of a street carrying a daily traffic of 50 tons per foot. The loss was roughly measured and pronounced to be about one-eighth of an inch for the 'hand-made brick' and one-quarter of an inch for the 'hydraulic pressed brick.' The experiment was then continued until the cart had made 148,692 transits—equivalent to 713,760 tons per foot of width. The wear of the 'hand-made brick' was then 'very carefully measured and the average was found to be 0.15 of an inch. Fifty per cent. of the brick showed a wear less than 0.12 of an inch, 34

* From Prof. Baker's book.

per cent. a wear between 0.16 and 0.19 of an inch, and 16 per cent. from 0.25 to 0.31 of an inch. Only three were broken.'

"The brick were 4 inches deep. Therefore, wearing off a depth of 0.15 of an inch from the "hand-made brick" was equivalent to wearing off 3.75 per cent. Then if 713,760 tons wore away 3.75 per cent., to wear away 1 per cent. required 190,000 tons. With the 'hydraulic pressed brick,' 95,000 tons caused a loss of 1 per cent."

II. At another time observations were taken on bricks on Second Street near Pine and on Pine Street, in St. Louis, Mo. These bricks had been in the street two years without requiring any repair.

Those on Second street are laid on loose sand and dirt. The bricks were taken up from that part of the street carrying the maximum traffic. "Four of those taken up were placed so as to give their combined height as worn, and by the side of them were placed four never used but of the same size. The difference between their respective heights was only half an inch, making only one-eighth of an inch wear to each brick. The edges of the bricks were broken off by their use and the surfaces rounded just enough, it would seem, to make a good foot-hold for the horses."

Bricks were also taken up between the rails of the street car line on Pine street.

"The old and new were placed side by side as in the former case, and *no appreciable surface wear was found*. But the edges were broken, making good foot-hold for the horses. Drivers of the cars on this track, with the experience of all the seasons, being consulted, said that no portion of the track was so *pleasant* for the horses and *safe from slipping* as this."

An official report states:

"The average daily tonnage carried over each foot in width of our pavements accommodating heavy traffic may be set down at 35 tons. . . . The injury to pavements by the hoofs of horses is estimated at about one-third of that caused by wheels, and, therefore, the total abrading action of the wheels and horses combined may be set down as being 35 plus one-third of 35, or say 50 tons per day per foot of width of pavement of streets carrying heavy traffic."

"The loss *in surface wear* during two years was one-eighth of an inch—equal to 2.8 per cent. of the depth of the brick. In this

time there had probably passed over the pavement $50 \times 365 \times 2 = 36,500$ tons. According to this basis 13,000 tons wore off 1 per cent."

III. From observations on brick taken from the pavement in front of a platform scale, Professor Baker writes as follows:

"The pavement had been down thirty-nine months to a day, and in that time 30,734 tons and 54,416 horses passed over it, as shown from the records of the loads weighed. In other words, there passed over the pavement 13,604 loads averaging 1.64 tons, and 13,604 loads averaging 0.62 tons. Each load was drawn by two horses. Excluding the effect of the horses' feet, the traffic was 15,367 tons *per foot of width*."

"An examination of the surface of the bricks showed conclusively that the only effect of the traffic had been to wear off the corners and edges of the bricks. This was checked by comparing the depth of the bricks exposed to the traffic with that of those in unexposed portions of the pavement. The wear of the brick due to the above traffic was estimated, in volume, by five independent observers, the writer being one, and the agreement was astonishingly close. The average loss as thus estimated was 1.01 per cent. Owing to the greater ease with which the square edges of the bricks are broken off, it is probable that the greater part of this wear occurred during the first part of the time; but assuming that the wear was uniform, we see that if 15,367 tons wore off 1.01 per cent., then 15,250 tons per foot of width wore off 1 per cent."

IV. Mr. Butler has kindly furnished the writer with the amount of traffic over the principal streets in Bloomington with the consequent annual wear. The daily traffic per foot of width is 250 tons and the annual wear amounts to one-eighth inch; that is 91,250 tons causes a wear of 3 per cent., or 30,417 tons wears off 1 per cent.

Tabulating these results we obtain the following:

										Surface Loss,	Tons.
										1 per cent.	190,000
No.	I.,	.	.	.	.	.	.	.	.	"	95,000
"	II.,	.	.	.	.	.	.	.	.	"	13,000
"	III.,	.	.	.	.	.	.	.	.	"	15,250
"	IV.,	.	.	.	.	.	.	.	.	"	30,417

Absorptive Power.—The absorptive power of a brick is deter-

mined by simply immersing it in water for twenty-four hours or longer. The results thus obtained are quite accurate enough for all practical purposes.

If a brick absorbs moisture continually during the rainy season, when the cold weather comes, the water freezes and the brick is consequently disintegrated. Therefore, in the selection of a paving brick, this test for absorption should always be made, and if any considerable amount of water is taken in by the brick, it may be set down at once as worthless for our purpose. In some localities it has been the practice to dip the bricks in creosote to make them impervious to water, but this at the best is but a temporary expedient and has only been resorted to in cases where the bricks were very porous, when they should have been rejected anyway as paving bricks.

Below is a table giving a comparison of the amounts of absorption of some of our best known bricks.

"Comparative Per Cents. of Absorption of Water."*

Name.	Spec. grav.	Bricks immersed for		
		3 days.	5 days.	10 days.
Ottawa, Ill.,	2.3507	3.22	3.80	4.12
London Mills,	2.2314	3.42	3.78	3.80
Burlington, Iowa,	2.2982	0.90	1.10	1.17
Galesburg, Ill.,	2.2432	5.32	5.54	5.545
Bardolph, Ill.,	2.0300	3.37	3.44	3.45
Empire, Ohio,	2.1700	5.00	5.85	5.864
Le Clair, Iowa,	2.1743	2.86	3.12	3.20
Bloomington, Ill., A.,	2.1852	3.79	3.92	4.06
Bloomington, Ill., B.,	2.3045	3.18	3.19	3.37
Bloomington, Ill., C.,	2.2269	1.87	2.20	2.70
Viriden, Ill., A.,	2.3166	3.10	3.12	3.82
Viriden, Ill., B.,	2.4150	7.67	7.96	8.71
Viriden, Ill., C.,	2.3601	7.11	7.48	8.70
Hayden block,	2.2861	3.25	3.38	3.64
Common brick,	1.8210	15.13	16.06	16.50

"All these brick, except the common red brick, come up to the standard of having a specific gravity of more than 2.0, and absorb less than one-tenth of their weight of water in ten days soaking, the Burlington brick absorbing least. The amount of water taken up varied almost directly with the vitrification of the brick; in nearly all of them the burning could have been carried a little farther to advantage."

* C. P. Chase in *Eng. News*, July 26, 1890.

Mr. Chase, in his paper from which the above table is taken, makes some very terse remarks on the matter of durability, which the writer is pleased to have the opportunity of quoting. He says: "Paving brick proper have had their reputation greatly injured by the use for paving of soft, inferior brick, sometimes tarred or creosoted. A good example of this is the brick paving of Nashville, Tenn. Quite a large amount of pavement was laid with creosoted brick; in a little while they begin to fail, and soon the whole country knew it. It was not until lately that the writer understood the real cause of the failure. In looking over one of last year's numbers of the *Engineering News*, an article on the failure of this pavement was found which, after noticing the failure, ended by saying: 'The brick were the common red brick, creosoted.' No wonder the pavement failed. Common red brick were never intended to resist the shock of heavy carts or blows from steel shod horses, and a brick that will take up tar or creosote will soon take up moisture. . . ."

"Unjust comparisons are made between granite or sandstone pavements of some of our large cities and brick pavements of the West, the persons making the comparisons forgetting that the first is usually on a hydraulic concrete foundation, and a brick invariably on broken stone or gravel."

It is the writer's opinion that brick as a street paving material would answer admirably in any of our large cities provided it had a good foundation; if not for the heavier travelled streets at least for those carrying the lighter traffic.

In 1887 there was a report made public to the effect that brick pavement put down in 1885 on Pearl street, Cincinnati, failed. The report gave no details. We can only conclude, and fairly too, in the light of our present knowledge, that it is highly probable the bricks were not of the right kind. The *Sanitary Engineer* of August 20, 1887 (now *Engineering and Building Record*) says, aptly: "It would be manifestly unfair to condemn the use of brick altogether in consequence of an indefinite report such as this is. We are inclined to believe that, under right conditions, there is a wide field to be usefully occupied by well made brick pavements."

COMPARISON OF FORMS OF BRICKS.

Common Bricks.—This brick offers many advantages over the patent bricks which are upon the market, chief among which are:

the ease with which they can be manufactured and burned; their interchangeability which allows a brick unfit for the upper course to be placed in the lower or else sold for building purposes, thus lowering the cost of pavement.

Patent Brick.—The distinguishing feature of these bricks is their increased size over the common brick, which brings us at once to a serious disadvantage, and that is the increase in width at the top which adds to the tendency of horses to slip. And further, the larger blocks are more difficult to manufacture and to burn. Since they are higher they are more apt to tip and thus give an uneven surface to the street. One slight advantage offered by an increase in height is the increased side-bearing surface which tends to support the load by simple friction. This advantage is, however, counteracted by the greater disadvantages already mentioned.

ADVANTAGES OFFERED BY BRICK AS A PAVING MATERIAL.

1. The material for their manufacture is abundant over a wide area in the United States.
2. When well laid with good brick the pavement is durable.
3. It is cheap in its first cost, the price ranging from \$1.00 to \$3.00 per square yard.
4. It is cheap and easy to relay, due to the regularity of the bricks.
5. It gives a smooth roadway, making it pleasant to ride over and reducing the tractive power and wear and tear on vehicles almost to a minimum.
6. The pavement can be easily cleaned and kept clean.
7. It gives a good foot-hold to horses. The surface of the brick is of that character which prevents horses from slipping over it. In this fact, and in that of the brick being calculated to fit the shoe of a horse, we have two of the strongest arguments in favor of the brick pavement.
8. It makes a pavement almost as noiseless as asphalt.

THE OPTICAL PYROMETER OF MM. MESURÉ AND NOUËLL.

By JOSEPH STRUTHERS.

THE temperature of a body can be approximately judged by the experienced eye unaided, and M. Pouillet has constructed a table, which has been generally accepted, giving the colors and their corresponding temperatures.

POUILLET'S TABLE.

	Degrees C.	Degrees F.
Incipient red heat corresponds to	525	977
Dull red heat corresponds to	700	1292
Incipient cherry-red heat corresponds to	800	1472
Cherry-red heat corresponds to	900	1652
Clear cherry-red heat corresponds to	1000	1832
Deep orange heat corresponds to	1100	2012
Clear orange heat corresponds to	1200	2192
White heat corresponds to	1300	2372
Bright white heat corresponds to	1400	2552
Dazzling white heat corresponds to	1500-1600	2732-2912

The results obtained, however, are unsatisfactory, as much depends on the susceptibility of the retina of the observer to light as well as the degree of illumination under which the observation is made.

The variations of color resulting from elevation of temperature can be sensibly increased, and thus more accurately noted, when the middle part of the spectrum (the yellow rays) is eliminated in such a manner as to preserve the extreme rays, the relative variations of which are greater. This is accomplished by interposing a piece of cobalt glass between the eye of the observer and the incandescent body.

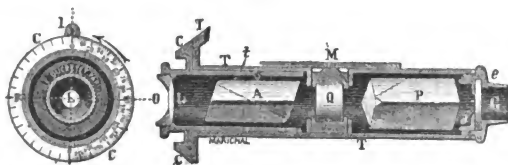
The color then observed, in place of changing only from red to white, goes from red to blue, always passing by the white.

This, however, is but little better than the eye alone.

A few optical methods can be employed for the estimation, if not for the measurement, of high temperatures, and they present a particular interest by reason of their simplicity, placing them within

the use of furnace men as well as scientists. All the methods used are based on the property which incandescent bodies possess of emitting, as the temperature is raised, a relative proportion, more or less considerable, of the most refractory rays of the spectrum. Thus, the color which the luminous body emits varies with the temperature, and the result of these variations can be rendered accurate in various ways, one of which being the rotation of the plane of polarization by quartz, and on this principle the pyrometer of MM. Mesuré and Nouell has been constructed. This pyrometer consists of two Nicol's prisms (Fig. 1). *A* and *P*, called

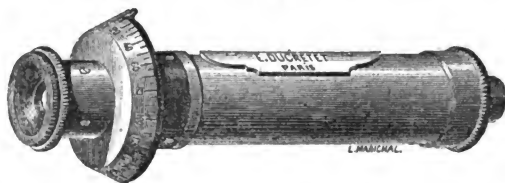
FIG. 1.



the analyzer and polarizer, enclosed in a sectional metallic tube (*t*, *T*, *T'*) one inch in diameter and about five inches in length. Between these Nicols is a plate of quartz, *Q*, cut perpendicularly to the plane of its axis, and can be removed by unscrewing the plate *M*. At one end of the tube is a lens, *L*, and at the other end is a removable cap, *E*, which allows the placing in position of the glass, *G*. There are two glasses used, one perfectly clear and the other having one side ground. The latter is used to tone down the color observed through the prisms. At the end *G* there is a continuation of the tube about five inches in length, fitted by thread and screw and removed when packed in case. Its object is to exclude luminous rays from other parts of the furnace than the particular part observed. The revolving scale, *C*, is fastened to the case of the analyzer and rotates with it. The support, having the index mark, *I*, upon it, is fastened to the case of the polarizer. When this mark is at 0° and 180° on the scale *C* (the quartz plate being removed) the two prisms are crossed and light is extinguished. When the quartz plate is replaced monochromatic light is observed in place of the darkness, the color of the light depending on the thickness of the quartz plate.

In this particular instrument described the color at 0° and 180° is green.

FIG. 2.



The whole apparatus (Fig. 2) is packed in a leathern case similar in appearance to those made for field-glasses, and can be suspended from the shoulder by a light strap.

The action of the pyrometer is as follows: The index mark is placed at 0° on the scale. The color then observed by ordinary daylight is green, with just a tinge of red. By rotation from 0° to 90° the green color at first is intensified, and at 90° (the line of separation between the green and red colors) the color observed at 0° is reproduced. This color is the one to be noted in subsequent observations and is called the "citron" color or shade. By rotation beyond 90° and up to 180° the red color is at first intensified and then gradually merges into the green, reproducing the citron color at 180° . The action between 180° and 360° is the same as just described between 0° and 180° . When luminous bodies are observed the angle of rotation from 0° necessary to produce the change of color to the citron shade varies with the temperature, and thus in itself serves to measure it.

The following scale is used, and corresponds to the degrees of rotation marked in the graduated circle:

Angle or Rotation Indicated by Degrees of Circle.	Temp. C.	Pouillet's Scale.
40° corresponds to	900° , Cherry-red.
46° "	1000° , Clear cherry-red.
52° "	1100° , Deep orange.
57° "	1200° , Clear orange.
62° "	1300° , White.
66° "	1400° , Bright white.
69° "	1500° , Dazzling white.

While much is claimed for its efficiency by the manufacturer, the

results obtained are only grossly approximate, inasmuch as the passage from green to red is progressive, and the exact shade of color to note (the "end reaction") is only approximate, varying with each observer, and even with the same observer it is impossible to reproduce the exact shade of color observed at graduation. At the temperature of 1400° C. the shade of color undergoes almost no change by the rotation of one degree. This would correspond to $33\frac{1}{3}^{\circ}$ C., which renders its use for scientific purposes of but little value.

Its special applicability is not so much for ascertaining exact temperatures, but more in the direction of constancy of temperature, and is of valuable assistance in running a furnace, the temperature of which must not vary. Under these circumstances the furnace man can become sufficiently expert to regulate the furnace temperature quite closely.

There are over a hundred of these pyrometers in use at various works in Europe, particularly in the manufacture of porcelain, glass and pottery, and also in some few foundries and gas-works.

The Keystone Cement Co., of Allentown, Pa., is the only reference given for its use in the United States, and from a recent communication from these works, they are not impressed with its utility, having abandoned its use entirely.

NEW METHOD FOR THE ANALYSIS OF TIN-ORES, AND FOR THE SEPARATION OF COPPER AND CADMIUM.

By J. S. C. WELLS, PH.D.

TIN-ORE.

THE methods for the analysis of tin-ores are so tedious and unsatisfactory that I was led, some time ago, to try and discover some simpler way of decomposing the ore, that being the chief difficulty in all the old methods.

In my first experiments, fusing the ore with borax was tried, and although this was found to effect the desired result, as far as

the decomposition of the ore, still it introduced other difficulties that caused me to give it up.

The borax, at the high temperature of the fusion, attacked the platinum of the crucible to such an extent that it became necessary to separate the platinum from the tin. Boracic acid, as was to be expected, acted the same as borax. The idea then occurred to me, that the ore might possibly be reduced in the same way as the artificial oxide, *i.e.*, by means of nascent hydrogen. On trying the experiment, I found that in this way the tin contained in the ore could easily be obtained in the metallic state. My first tests were made as follows: About one gramme of the finely pulverized ore was placed in a large test-tube with a few pieces of zinc and some dilute hydrochloric acid. The first trials were made on an ore from Cornwall, and it was found to be very easily reduced. A sample of Durango ore, consisting of nearly pure cassiterite was then tried, but the reduction did not take place as readily as with the ore from Cornwall; the reduction of the latter was nearly complete at the end of an hour, whilst the former at the end of three hours showed little change. I then added a piece of platinum with the zinc and acid, and found the result to be very satisfactory, the ore being quickly reduced. Heating the test to boiling was also found to aid the reaction. The addition of the platinum also facilitates very much the subsequent solution of the reduced tin in hydrochloric acid, tin alone dissolving but slowly in the acid.

It is advisable to shake the test frequently during the reaction, so as to keep the ore in contact with the zinc and platinum. If this is not done, the ore settles to the bottom and the reduction takes place very slowly, if at all.

As soon as the decomposition of the ore appears to be complete, the remaining zinc and the reduced tin are dissolved in hydrochloric acid and filtered from any undecomposed ore or gangue. This residue should again be tested in the same way, with fresh zinc, platinum, and hydrochloric acid, to see if all the tin has been extracted by the first operation. After the tin has been obtained as chloride, it can, of course, be determined by any of the usual methods.

Instead of dissolving in hydrochloric acid, the tin might be dissolved in ferric chloride, after removal of the excess of zinc, and then determined volumetrically. The metal being in such a finely divided state would be very easily soluble in this reagent.

SEPARATION OF COPPER AND CADMIUM.

I find that copper and cadmium can be easily separated by the following method :

To the neutral solution, containing these metals (ammonia salts must not be present) add sodium thiosulphate (hyposulphite) until the solution becomes colorless, then add sodium carbonate, and the cadmium will be precipitated as carbonate (white); filter, and to the filtrate add HCl, and boil, and the copper will be precipitated as sulphide. To use this method in the ordinary course of analysis, the solution, after removal of the bismuth, would have to be evaporated to dryness and ignited so as to remove all ammonia salts.

PROPERTIES OF PRECIPITATES, ETC.

By E. WALLER, PH.D.

(Concluded from p. 248.)

H₂TiO₃ or Titanic Acid.

Rem.—Two forms, one tolerably easily soluble in acids, the other insoluble, except in very strong acids or by fusion, are known to exist. The "insoluble" form is obtained by boiling the solution acid with sulphuric. The small amounts of phosphoric acid present in iron ores and other minerals interfere somewhat with the complete separation on boiling.

Cond.—Dilute solution containing but little free H₂SO₄. HCl and chlorides should be absent. Long boiling is necessary, the bulk of the solution being maintained. Fe, if present, should be in the ferrous form. HC₂H₃O₂ favors the precipitation. The best conditions for the separation of titanic acid are boiling an acetic acid solution reduced by SO₂.

Sol.—The soluble form is attacked by the same solvents as Fe₂(OH)₆. The "insoluble" form is slowly soluble in hot concentrated HCl or H₂SO₄, or by fusion with KHSO₄.

Contam.—Fe₂O₃, Al₂O₃, SiO₂ and P₂O₅. Some iron inevitably is converted to Fe₂O₃, and separates with the precipitate. By re-solution, reducing and re-precipitation, almost all can be removed.

Al_2O_3 is prevented from contaminating the precipitate by the larger proportion of free acid. SiO_2 may be expelled after ignition by treating with HFl (or NH_4Fl) and H_2SO_4 . P_2O_5 by fusion, for some little time, with Na_2CO_3 , and washing with dilute Na_2CO_3 solution, which leaves behind Na_2TiO_3 , soluble in acids.

Ign.—Converted to TiO_2 . Retains some SO_3 ; removable by adding a few pieces of solid ammonium carbonate and re-igniting. Volatilized by ignition with HFl , alone or with an insufficient amount of H_2SO_4 .

$(x\text{Na}_2\text{O}, \text{TiO}_2)\text{Na}_2\text{TiO}_3$. *Sodium titanate.*

Rem.—Usually obtained by fusing material containing TiO_2 and P_2O_5 for some time, to convert them into sodium salts, and then to separate them by lixiviation. Chiefly of service as a step in the determination of phosphorus in titaniferous ores.

Cond.—Long fusion at a fairly high temperature is necessary. A repetition of the fusion of the portion insoluble in water, with a fresh lot of sodium carbonate, is at least necessary in order to prove the efficiency of the first fusion.

Sol.—Dissolved by acids; to some extent by water alone. Insoluble in solution of Na_2CO_3 . The washing (leaching) of the insoluble portion should be continued until the washings begin to run cloudy.

Contam.—As usually applied to iron ores or precipitates from solutions thereof, the insoluble residue may contain besides sodium titanate, Fe_2O_3 , acid sodium silicates, alkaline earth carbonates, etc.

$2\text{ZnCO}_3 \cdot 3\text{Zn}(\text{OH})_2$. *Basic Zinc Carbonate.*

Rem.—Usual precipitant, Na_2CO_3 . Flocculent at first, becoming more granular by boiling.

Cond.—Solution should not contain caustic or bicarbonated alkalies or any ammonia salts. If CO_2 is evolved by addition of the reagent, it must be boiled out. Only fixed alkalies besides the zinc should be present.

Sol.—Dissolved by dilute acids, fixed caustic alkalies, bicarbonates and ammonia salts; also by organic solutions. A very large excess of fixed alkaline chlorides hinders or partially prevents the precipitation. Insoluble in water and small amounts of fixed alkaline carbonates.

Contam.—Alkaline carbonate, necessitating several washings by decantation with boiling water to remove it. Fe_2O_3 , — Al_2O_3 , — SiO_2 . By dissolving the precipitate in HCl after ignition, Al_2O_3 and SiO_2 are left insoluble; on precipitating the solution with ammonia, redissolving and reprecipitating two or three times, $\text{Fe}_2(\text{OH})_6$ is separated. These impurities may then be ignited, weighed and deducted.

Ign.—Converted to ZnO , which in itself is not volatile. In contact with C or reducing substances, metallic zinc which is volatile may be formed.



Rem.—Usual precipitant, $\text{NaNH}_4\text{NPO}_4$. Some prefer Na_2HPO_4 in presence of ammonium salts. The best method of procedure is to add the alkaline phosphate to the acid solution and then to neutralize the hot solution by adding ammonia, little by little, finally to heat, immersing the beaker in a boiling water bath, until free NH_3 is expelled and the precipitate is crystalline. The solution containing the precipitate cannot be boiled without bumping vigorously. The precipitate can be dried at 100° and weighed as ZnNH_4PO_4 or ignited and weighed as $\text{Zn}_2\text{P}_2\text{O}_7$.

Cond.—Oxalates should be absent. Large excess of ammonium chloride or acetate should be particularly avoided. Practically, the solution should only contain alkalies besides the zinc.

Sol.—Dissolved by acids, excess of ammonia, ammonium oxalate chloride or acetate, especially if hot. The solvent effect of the chloride and some other ammonium salts is to a very great extent diminished by the use of an excess of alkaline phosphate (about three times as much as is required to afford the compound).

Ign.—If heated up too rapidly, some loss may be experienced. In contact with C , a partial reduction to metal and consequent loss may occur. The precipitate should be carefully separated from the filter paper and the same burned separately, or it may be dissolved by means of dilute nitric acid into a weighed capsule and the solution evaporated and finally ignited.

After ignition the precipitate is usually opaque, white, somewhat sintered together; sometimes, without apparent reason, it fuses to a glass.



Rem.—Usual precipitant, H_2S in neutral solution, or one acid with some organic acid (acetic, citric, formic, etc.). Precipitation

can be effected (though slowly) in H_2SO_4 solution; the smaller the proportion of free H_2SO_4 , the more complete the separation. NH_4Cl favors its separation in a granular form, and checks a tendency to run through the filter paper, which it sometimes exhibits, especially when the solution contains free ammonia. Oxidizes slowly on exposure to the air.

Cond.—Solution should be alkaline or acid only with some of the weaker organic acids. Free mineral acids prevent the precipitation to a greater or less extent. H_2SO_4 has the least effect, HCl the greatest. Boiling facilitates the formation of the precipitate, but increases the solvent power of acids upon it. Fe should be absent.

Sol.—Dissolved by dilute HCl and HNO_3 or by moderately strong H_2SO_4 when hot. Insoluble in alkalis, neutral solutions and in organic acids though the latter, when in excess, retard somewhat its formation. Free ammonia has a similar effect.

Contam.— MnS or Ni, Co and Fe sulphides. Fe should be separated previously. From the others it may be freed by re-solution, neutralizing and reprecipitating.

$2MnCO_3, H_2O.$

Rem.— Na_2CO_3 usual precipitant. When precipitated cold, white and flocculent—by boiling becomes granular and assumes a light brownish shade, probably from oxidation.

Cond.—Solution should not contain bicarbonates or ammonia salts. If CO_2 is evolved by the addition of the precipitant to an acid solution, it must be boiled out. Solution must be rendered alkaline by the reagent.

Sol.—Dissolved by dilute acids, bicarbonates, ammonia salts and solutions containing citrates, tartrates, sugar, etc. Also by solutions containing large amounts of fixed alkaline salts.

Contam.—Alkaline carbonate requiring several washings (by decantation) with boiling water to remove it. Fe_2O_3 ,—removed by repeated solution in HCl and reprecipitation with ammonia after igniting the precipitate.

SiO_2 by dissolving the ignited precipitate in acid and filtering off.

Ign.—In contact with air gives black Mn_3O_4 , non-volatile. Recent investigations tend to show that the composition is not abso-

lutely constant. If alkali has not been washed out, ignition in contact with the air affords alkaline manganate.



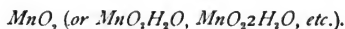
Rem.—Usual precipitant, $\text{NaNH}_4\text{HPO}_4$ or Na_2HPO_4 in presence of ammonium salts. Best managed by adding the reagent to the acid solution of Mn, boiling and then adding ammonia little by little to the boiling solution, until a slight excess is present, then heating on the water-bath until the precipitate assumes *completely* the crystalline form.

Cond.—The Mn must be entirely in manganous form, and solution alkaline, though not strongly so. An excess of phosphate (about three times as much as is required to form the combination) must be present. Oxalates should be absent, as well as excessive amounts of ammonia salts or free ammonia.

Sol.—Dissolved by acids. Somewhat soluble in decided excess of ammonia, in NH_4Cl and some other ammonium salts. The solubility in these last is neutralized by the presence of an excess of the precipitant. When too large proportion of ammonia is present, the precipitate, which should be white or faintly pinkish, becomes deeper in color, sometimes quite brown.

Contam.—Practically none if bases forming insoluble phosphates are absent and moderate care is used in washing.

Ign.—Converted to $\text{Mn}_2\text{P}_2\text{O}_7$. The temperature should not be too rapidly raised or there may be some loss. The peculiar nacreous lustre of the precipitate is more pronounced after ignition. Sinters somewhat. Not volatile.



Rem.—For separation in two separate cases. 1. From acetate solution by addition of an oxidizing agent, usually Br. 2. From a boiling solution in nitric acid, by addition of crystals of KClO_3 . Also (3) obtained in titration by the Volhard method—adding standard (volumetric) solution of $\text{K}_2\text{Mn}_2\text{O}_8$ to a solution neutralized by ZnO. In all cases the precipitate probably contains some water of constitution (hydrated oxide).

Cond.—Absence of HCl or other halogen acids, lower oxides of nitrogen or reducing agents. In Case 1 a fair proportion of alkaline acetate must be present, to supply base to the mineral acid which might otherwise be set free. Boiling solution necessary.

Sol.—Dissolved or prevented from forming by dilute mineral acids, particularly HCl. Insoluble in moderately strong acetic or in concentrated nitric. When formed it is soluble in strong HCl, forming temporarily an olive-green solution of Mn_2Cl_6 , which becomes practically colorless $MnCl_2$ by heating. Readily dissolved by HCl or H_2SO_4 in presence of reducing agents (SO_2 , $H_2C_2O_4$, $FeSO_4$, etc.).

Contam.—Salts of fixed alkalies, Fe_2O_3 , ZnO .

Ni (Electrolytic).

Rem.—Requires a stronger current than Cu—two or three Bunsen cells (12 to 14 c.c. oxyhydrogen gas per minute). The rapid deposition of the metal is somewhat checked as soon as a coating of nickel has formed, tending to be slower, the thicker the coating. This peculiarity is most marked in cold solutions. In preparing for weighing it is treated as electrolyzed Cu, by washing with water, then with alcohol, and drying at a gentle heat.

Cond.—Solution should contain no other metals of the $(NH_4)_2S$ or H_2S groups. Chlorides should be preferably absent. The solution should contain the nickel as double ammonium nitrate, sulphate or oxalate (the latter most advantageous) and excess of ammonia. The operation is more rapid at $70^\circ C$. In consequence, ammonia requires to be added from time to time.

Sol.—Dissolves readily in HNO_3 , especially with the aid of heat. Slowly soluble in strong solution of $(NH_4)_2C_2O_4$.

Contam.—Co, Fe and Zn, being precipitated from oxalate solution under the same or similar conditions, may be present in the coat unless previously separated.

Ni(OH)₂ and Ni₂(OH)₆.

Rem.—Usual precipitant, KOH or NaOH. If the solution contains free halogens, or hypochlorites, hypobromites, etc., $Ni_2(OH)_6$ may be precipitated *black*. The most marked characteristic of the precipitate is the persistency with which it takes up and retains impurities derived from the solution.

Cond.—No bases other than fixed alkalies should be present.

Sol.—Dissolved readily by mineral acids. Soluble or prevented from precipitation by NH_4 salts and tartrates, citrates, etc., or other organic solutions.

Contam.—Alkali used as the precipitant, Fe_2O_3 , Al_2O_3 and silica

from the reagents. The precipitate requires thorough washing by decantation with boiling water. After ignition and weighing, it should be dissolved in HCl, which leaves SiO_2 and Al_2O_3 . From this solution the iron should be precipitated by ammonia, filtered, redissolved and reprecipitated again, and these impurities ignited, weighed and the weight deducted.

Ign.—If only moderately, some Ni_2O_3 is contained in the precipitate. If strongly ignited, it all becomes *green* NiO. The tint is not a pure green like that of ignited Cr_2O_3 , but lighter and somewhat muddy.

NiS.H₂O.

Rem.—For separation only. Usual precipitant H_2S in weak acetic solution, or $(\text{NH}_4)_2\text{S}$ followed by acetic acid in excess. Oxidizes easily in contact with the air, with partial formation of NiSO_4 . Should be washed by and kept in contact with H_2S water during manipulation.

Cond.—Absence of other members of $(\text{NH}_4)_2\text{S}$ or H_2S group. NH_4Cl in the solution assists materially its separation in the granular form. Free ammonia, on the other hand, tends to keep the precipitate suspended in the liquid. The solution should be only slightly acid with acetic acid or else barely alkaline.

Sol.—Formation of the precipitate prevented by moderate amounts of free acetic acid or mineral acids. When once formed, it is insoluble in these menstrua unless oxidized by exposure to air, which may easily occur. Somewhat soluble in $(\text{NH}_4)_2\text{S}$. To meet these peculiarities of the compound, the solution should be rendered alkaline with ammonia, and H_2S passed in, or $(\text{NH}_4)_2\text{S}$ added, and when the precipitate is *fully formed*, the solution is acidified with acetic acid, and the precipitate allowed to settle (which occurs readily if NH_4Cl is present). Soluble in hot HNO_3 or in aqua regia. Soluble in KCy.

Contam.—Sulphides of $(\text{NH}_4)_2\text{S}$ group, if not previously separated.

Ign.—Gives mixture of oxide and sulphate.

Co₂(NO₂)₆ 6KNO₂.

Rem.—Usual precipitant, KNO_2 in a solution slightly acid with acetic. Yellow crystalline precipitate, forming best in a warm solution.

Cond.—Solution should contain only Co, Ni and K salts. It should be a nearly saturated solution of $KC_2H_3O_2$, containing but little free acetic acid.

Sol.—Dissolved by H_2O , acids, NH_4 salts, NaCl and most other Na salts. Insoluble in $KC_2H_3O_2$ and other K salts. Insoluble in dilute acetic, and in alcohol. The precipitate should be first washed with a 10 per cent. solution of $KC_2H_3O_2$, and the latter salt finally removed by washing with alcohol.

Contam.—If Ca or other alkaline earths are present, a yellow NiCa nitrite, similar in properties (solubility, etc.) to the Co compound will separate. Pb also gives a similar compound. Care in washing off K salts is necessary.

Ign.—By addition of H_2SO_4 and ignition, the precipitate is converted to $3K_2SO_4 + 2CoSO_4$. One method of management consists in dissolving the washed precipitate through the filter with a little hot dilute H_2SO_4 into a weighed capsule, evaporating and igniting. Some $KHSO_4$ may remain after ignition; removed by addition of a small lump of solid ammonium carbonate and igniting.

CoS.H₂O.

Rem.—For separation only. Properties essentially the same as those of $NiS.H_2O$. Precipitant, H_2S in weak acetic solution or $(NH_4)_2S$. Oxidizes readily in the air when moist, some sulphate being formed. Should be kept in contact with H_2S water during filtration.

Cond.—Absence of other members of $(NH_4)_2S$ or H_2S group. NH_4Cl assists the separation. Unlike $NiS.H_2O$, free NH_4OH does not materially influence the separation. Solution should be preferably *slightly* acid with acetic before filtration (*vid.* $NiS.H_2O$).

Sol.—Formation of the precipitate prevented by moderate amounts of free acetic or mineral acids. When once formed, however, it is insoluble in these menstrua. Of the ordinary mineral acids, HCl has the strongest preventive effect, H_2SO_4 the least; but a very small amount of free H_2SO_4 retards the separation markedly. Soluble in hot HNO_3 or in aqua regia; also in KCy.

Contam.—Usually accompanied by Ni or other members of the group if not previously separated.

Ign.—Affords mixture of oxide (Co_3O_4) and sulphate.

Cu.

Rem.—Obtained by electrolytic deposition on platinum from acid solution. Free HNO_3 gives a bright coating. Too strong a current gives a spongy, imperfectly adherent coat.

Cond.—Sulphuric acid solution preferable, with or without a few drops of nitric acid. Not over 8 per cent. of free acid should be present. Chlorides disadvantageous. Organic acids (as citric, etc.) should not be present, since they afford a brittle deposit containing organic elements.

Sol.—Easily soluble in HNO_3 . When that acid is present at the end of the operation, flood out the dish with water before breaking the current. Deposit dissolved or prevented from forming by Cl , lower oxides of nitrogen or too strong acid.

Contam.—If free HNO_3 is absent, As, Sb or Bi may occur in the deposit, rendering it blackish. A black coloration is, however, sometimes due to other causes. If free HNO_3 is present, Zn if present, begins to deposit (imperfectly) as soon as all the Cu is precipitated. Pb and Mn may separate from the solution on the other pole, as PbO_2 or MnO_2 , and in case a dish is used these oxides may fall to the bottom and be caught in the deposit. $\text{SnO}_2(\times \text{H}_2\text{O})$ may also separate from the solution and be caught in the deposit in the same way.

Ign.—Easily oxidized by heating in air or oxygen. After deposition and washing with water, the water should be rinsed off with alcohol, the alcohol drained off and the dish dried at a temperature which can be borne by the hand, not higher.

CuO or $3\text{CuO} \cdot \text{H}_2\text{O}$.

Rem.—Usual precipitant, KOH or NaOH in a boiling solution or one subsequently boiled. Na_2CO_3 or K_2CO_3 may also be used in the same manner. The precipitate, at first the light bluish hydrate or basic carbonate, becomes black on boiling from elimination of H_2O .

Cond.—Alkaline solution, not containing bases, the hydrates of which are more or less insoluble. NH_4 salts and organic substances should be absent.

Sol.—Dissolved by acids, also by NH_4 salts and organic solutions, as citrates, etc. Precipitation prevented by alkaline bicarbonates, especially by KHCO_3 .

Contam.—Chiefly the alkali of the precipitant, which is washed out with great difficulty. Some SiO_2 dissolved by the reagent from the bottle in which it was kept, or otherwise introduced, may also be present. Left behind on dissolving in acid the ignited and weighed precipitate.

Ign.—Obtained as black CuO . Some reduction to the metallic form by contact of C may occur, but as the metal is not volatile it is readily restored by ignition with a few drops of HNO_3 . The use of platinum where reducing substances may be mingled with the precipitate is inexpedient. Precipitate quite hygroscopic after ignition.

CuS.

Rem.—Usually for separation. When for determination, treated as suggested under "*Ign.*" for production of Cu_2S . Has ordinarily a brown to black color, but when precipitated along with sulphur, has an orange-red color.

Cond.—Acid solution usually used, though not indispensable. Precipitation can be effected promptly in presence of moderately strong H_2SO_4 , or of HCl if not too strong or hot. If HNO_3 is present, the solution must be dilute and cold.

Sol.—Soluble in hot dilute HNO_3 and in HCl when hot and moderately strong. Somewhat soluble in $(\text{NH}_4)_2\text{S}$, especially if polysulphides are present. Insoluble in HCl or H_2SO_4 , or in NaHS or KHS , unless polysulphides are present.

Ign.—Partly reduced to Cu with C. Converted to Cu_2S by mixing with sulphur and igniting in a current of hydrogen (in a Rose crucible).

PbSO₄.

Rem.—Usual precipitant, H_2SO_4 . By digestion with alkaline carbonates or bicarbonates, it is converted to PbCO_3 .

Cond.—Solution should be acid with H_2SO_4 and contain little or no free HNO_3 or HCl . The larger the proportion of these acids and the warmer the solution, the more H_2SO_4 required. NH_4 salts and salts of organic acids should not be present. Also, any large proportion of chlorides.

Sol.—Readily soluble in concentrated mineral acids, H_2SO_4 as well as the others, but less soluble in dilute H_2SO_4 than in pure water. Soluble in $\text{Na}_2\text{S}_2\text{O}_3$, in caustic alkaline solutions, and in ammonia salts, notably those of organic acids especially when free

ammonia is present. $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$ and $(\text{NH}_4)_3\text{C}_6\text{H}_5\text{O}_7$ may be used for this purpose. To obtain PbSO_4 for ignition and weighing, the usual procedure is to wash off all other substances with very dilute H_2SO_4 and then to remove the latter before drying by washing with alcohol.

Contam.—If all other sulphates (than PbSO_4) have not been removed by washing with dilute H_2SO_4 as just described, the precipitate may be contaminated with sulphates, most of which are insoluble in alcohol.

Ign.—Unchanged by a moderate heat. At temperatures usually higher than are ordinarily obtained with a Bunsen burner, the compound may fuse, but without volatilization.

With C partially or entirely reduced to Pb, PbS , etc., which are volatile. The precipitate should be separated from the filter paper, which should be separately incinerated (in the cover of the *porcelain* crucible) with the aid of a few drops of concentrated HNO_3 and H_2SO_4 , the ashes and precipitate united and the whole ignited before weighing.

PbCrO₄.

Rem.—Usual precipitant, $\text{K}_2\text{Cr}_2\text{O}_7$ in solution acid with acetic.

Cond.—Bi, Ba, Ag and Fe should not be present. Solution should not contain chlorides or large amounts of alkaline salts, and should be acid with no stronger acid than acetic. Alkaline citrates, tartrates, etc., should be absent.

Sol.—Dissolved by moderately strong mineral acids and by caustic alkalies. HCl reduces the chromium partially or entirely to Cr_2Cl_6 , more readily in the presence of acetic acid, alcohol or other carbon compounds. Soluble in hot moderately concentrated solutions of $(\text{NH}_4)_2\text{C}_2\text{H}_3\text{O}_2$. Insoluble in very dilute HNO_3 .

Contam.—Possibly Ba, Bi or Hg, chromates, etc. If much Fe is present, the precipitate is likely to contain that element, probably as $\text{Fe}_2(\text{CrO}_4)_3$.

Ign.—Alone fuses and parts with some oxygen. With C it is more easily decomposed, some metal being reduced. On account of these properties the precipitate is usually dried on a weighed filter for estimation. The Gooch filter in which, if paper is used, it need be only about the size of a five cent piece, is especially advantageous for this purpose.

PbS.

Rem.—Usual precipitant H_2S . Partially decomposed by drying at $100^\circ C$. Used for separation.

Cond.—Solution may be slightly acid, neutral or alkaline. HCl interferes most with complete separation, HNO_3 less, and H_2SO_4 least. If the solution is acid with any large proportion of these, the precipitation is best effected in the cold.

Sol.—Dissolved by dilute boiling HNO_3 , though that solvent almost invariably affords some $PbSO_4$. Of concentrated acids hot HCl is the best solvent, since with either HNO_3 or H_2SO_4 , some $PbSO_4$ will form in such a way as to protect a portion of the sulphide. Soluble in $Na_2S_2O_3$.

Ign.—Volatilized. Easily reduced to metal by ignition with C .

AgCl.

Rem.—For determination of Ag , usual precipitant, HCl . For determination of Cl , usual precipitant, $AgNO_3$. Separates most readily in presence of an excess of silver salts. Partially decomposed by heating with strong HNO_3 or H_2SO_4 . Darkens in strong daylight, more quickly in sunlight, but may become very dark without material loss of weight.

Cond.—Acid solution, absence of any notable quantities of alkaline chlorides or other alkaline salts.

Sol.—Partially dissolved by moderately strong and hot HCl or HNO_3 . Somewhat soluble in alkaline and alkaline earth chlorides and nitrates. Readily soluble in NH_4OH , in KCy and in $Na_2S_2O_3$. In the latter, less readily if the substance has been changed by light.

Ign.—Fuses at a low temperature (dull red) and volatilizes at a little higher temperature. Easily reduced to metal by strong heat, especially when mixed with Na_2CO_3 or C . On burning the filter paper (which should be separated from the precipitate), the ash should be treated with HNO_3 to obtain $AgNO_3$, then a drop or two of HCl is added to restore $AgCl$, and the whole after drying cautiously heated to incipient fusion.

As₂S₃.

Rem.—Usually precipitated by H_2S in HCl acid solution. From the solution of arsenic sulphides in alkaline polysulphide, the addition of acid separates As_2S_3 . As_2S_3 requires very thorough dry-

ing before weighing, the last portions of water being driven out with difficulty.

Cond.—Solution acid, with some mineral acid (HCl preferable). As should be in triad form. If in pentad form, it is slow to reduce and precipitate ($\text{As}_2\text{S}_3 + \text{S}_2$) by prolonged action of H_2S and warming.

Sol.—Dissolved by alkaline solutions (hydrates, carbonates or sulphides), also by aqua regia, fuming nitric acid, water solutions of chlorine, bromine, etc. In a neutral solution, scarcely any precipitation occurs. Insoluble in strong HCl, even on boiling. Practically insoluble in H_2SO_4 . Dissolved by KHSO_3 .

Ign.—Readily volatilized without change of composition.

$\text{MgNH}_4\text{AsO}_4$.

Rem.—Usual precipitant MgCl_2 in ammonia solution containing alcohol. Precipitate white, crystalline closely resembling MgNH_4PO_4 .

Cond.—Solution alkaline with ammonia, containing a minimum amount of NH_4Cl , and 25 to 30 per cent. of alcohol. No sulphates or other compounds, partially or entirely insoluble in alcohol of this strength, should be present. The As must be in pentad form (a condition realized in solutions containing alkaline polysulphides).

Sol.—Dissolved by acids, or on application of heat. Somewhat soluble in water and in NH_4Cl , an effect partly neutralized by presence of ammonia and alcohol, in which it is insoluble.

Contam.—Basic Mg salts, sulphates and other salts partially or entirely insoluble in diluted alcohol.

Ign.—Partially volatilized if heated up quickly. By slow heating it is dried and finally altered to $\text{Mg}_2\text{As}_2\text{O}_7$, which is non-volatile. With C partly volatile. A convenient method of management consists in dissolving the washed precipitate through the filter by dilute HNO_3 into a weighed capsule, evaporating, igniting slowly and finally intensely.

Sb_2S_3

Rem.—Usually precipitated by H_2S in acid solution, or by acidifying solutions of sulphantimonite.

On drying, the precipitate does not surrender all H_2O until the temperature is raised to 200°C , when it becomes black. This

degree of heat is liable to char the paper when dried on a weighed filter.

By the action of oxidizing agents (Br, HNO_3 , HgO , etc.,) it is converted to Sb_2O_4 .

Cond.—Solution slightly acid and moderately dilute. An excess of H_2S causes a more rapid separation of the precipitate. If too acid or too concentrated the precipitation may be imperfect.

Sol.—Precipitate dissolved or prevented from forming by moderately concentrated acids, especially HCl . H_2SO_4 has much less effect. The preventive effect is increased with the temperature. Tartaric acid in the solution assists precipitation.

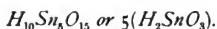
Dissolved by fixed alkalis or alkaline sulphides.

Scarcely soluble in ammonium carbonate or KHSO_3 .

Somewhat soluble in $\text{H}_2\text{C}_2\text{O}_4$, but insoluble in it if boiled in presence of an excess of H_2S . (Separation from tin.)

Contam.—S usually accompanies the precipitate. To remove this the water is first displaced by alcohol, and the S dissolved out by CS_2 .

Ign.—Partially or entirely volatilized by ignition alone, or with reducing agents. Mixed with 30 to 50 times its weight of HgO and ignited, it is converted to Sb_2O_4 , which is stable at the ordinary temperature of ignition. Frequently, however, it is converted to Sb_2O_4 by Br or HNO_3 before ignition.



Rem.—The above is called the "insoluble" form of hydrated stannic oxide, because not readily soluble. It is usually obtained by boiling slightly acid (HNO_3 or H_2SO_4) solutions containing the soluble form in partial suspension, or by boiling weakly acid solutions (of stannic compounds) containing neutral alkaline salts (NH_4NO_3 , NaNO_3 , Na_2SO_4 , etc.). The presence of acetates assists the separation.

Cond.— HCl or chlorides should be small in amount, preferably entirely absent. Solution should be acid, tolerably dilute, and boiled for some time.

Sol.—The "soluble" form (obtained by neutralizing stannic solutions with caustic or carbonated fixed alkalis) is readily soluble in excess of the alkali or in acids. The "insoluble" form is only soluble with difficulty in HCl , or in caustic alkali, and practically insoluble in dilute HNO_3 or H_2SO_4 .

Contam.—As and Sb oxides, which should have been removed previously. In analyses of bronzes, etc., CuO removed by long digestion with dilute HNO_3 . SiO_2 , removable by treatment with HF and H_2SO_4 . Fe_2O_3 , removed by fusion with NaOH or Na_2CO_3 and after further treatment by well-known methods, separating the Fe_2O_3 , which is weighed and deducted. This operation is usually performed upon a weighed portion of the precipitate.

Ign.—Requires intense heating to remove all H_2O . Not easily reduced to (volatile) Sn by C, though such reduction is possible, on igniting the precipitate. Volatilized as chloride by ignition with NH_4Cl . Otherwise not volatile at high temperatures.

SnS_2 .

Rem.—Usually precipitated by H_2S in acid solution, or by acidifying solutions of alkaline sulpho-stannate. Obtained for purposes of separation, or for determination as SnO_2 after oxidizing. Disposition to run through the filter checked by alkaline acetates or nitrates, etc.

Cond.—Solution slightly acid, moderately dilute. Precipitation promoted by acetates, interfered with by alkaline oxalates or oxalic acid.

Sol.—Moderately concentrated acids, especially HCl , dissolve or prevent precipitation. The influence is more marked the more concentrated the acid, or the higher the temperature. Soluble in a boiling solution containing free $\text{H}_2\text{C}_2\text{O}_4$. (Separation from Sb.)

Ign.—If rapidly and strongly heated, some SnS_2 may be volatilized. By moderate heating with access of air, SnO_2 forms without loss. It is, however, usual to assist the oxidation with a few drops of HNO_3 , added from time to time.

Ammonium Phosphomolybdate. $12\text{MoO}_3(\text{NH}_4)_3\text{FO}_4 +$.

Rem.—Yellow finely crystalline precipitate. Precipitant $(\text{NH}_4)_2\text{MoO}_4$ in HNO_3 solution. The ratio of MoO_3 to P_2O_5 in the precipitate varies according to the proportion of substances present in the solution (NH_4NO_3 , $\text{Fe}_2(\text{NO}_3)_6$, etc.), the proportion of free acid, the kind of acid, the length of time elapsing before filtering, and the temperature at which it is effected. With the same or closely similar conditions, the ratio of MoO_3 to P_2O_5 is essentially the same. Precipitation promoted by agitation. When precipita-

tion is complete, the precipitate settles rapidly after stirring. Precipitated under the conditions described by Emmerton (volumetric determination of P in irons), the ratio of MoO_3 to P_2O_5 is 24 to 1.

Cond.—Solution should be acid with HNO_3 . Too much free HNO_3 retards or may prevent complete precipitation; too little allows Fe_2O_3 to come down with it, in which case the color is more orange. An excess of the precipitant should be present; also at least 10 gms. of NH_4NO_3 for every 0.1 gm. or less of P present. Temperature should be 70 to 85° C. Below 70° the separation is very slow, whereas on boiling (other conditions being right) MoO_3 or Fe_2O_3 may accompany the precipitate. Reducing agents, organic acids, silica, chlorides and HCl should be absent. H_2SO_4 and sulphates retard precipitation. If the precipitate is to be dissolved for volumetric estimation, in a solution of material containing but little iron, some iron should be added to give correct results, or the standard should be obtained with material of the same character.

Sol.—Readily dissolved by NH_4OH and other alkalis; also by alkaline phosphates. If the ammonia is too strong, however, the solution will be turbid with $(\text{NH}_4)_2\text{MoO}_4$. Dissolved or decomposed by water alone, the more readily, the higher the temperature. Precipitation prevented by tartaric acid or organic substances of that class. Somewhat soluble in HCl , or moderately strong H_2SO_4 and HNO_3 . Insoluble in weakly acid solutions and acid solutions of NH_4 salts. Solution for washing should contain 1 per cent. HNO_3 and 10 per cent. NH_4NO_3 , or a corresponding amount of H_2SO_4 and $(\text{NH}_4)_2\text{SO}_4$.

Contam.—Arsenio-molybdate, silica, Fe_2O_3 , TiO_2 .

Arsenio-molybdate precipitates the less readily the lower the temperature. By allowing the solution to stand for about two days at 40° C., the phospho-molybdate may be precipitated free from arsenic. When present, however, As is separated either before or after.

Silica, either as hydrated SiO_2 or as silico-molybdate (the existence of which is disputed), may be present. By allowing the ammonia solution to stand for some time after addition of NH_4Cl , the flocculent silica separates and may be filtered off.

Fe_2O_3 in the precipitate often causes it to separate in crusts on the sides of the beaker. On attempting to dissolve in ammonia, yellow to red $\text{Fe}_2(\text{OH})_6$ mixed with $\text{Fe}_2(\text{PO})_2$ remains undissolved.

After washing with ammonia, this residue is dissolved in HNO_3 , the solutions united and reprecipitation effected, after acidifying with HNO_3 .

Hydrated TiO_2 (which retains P_2O_5) can be separated by fusing the portion insoluble in ammonia for some time with Na_2CO_3 (*vid.* Na_2TiO_3), leaching with water, and in the water solution reprecipitating with the molybdate reagent.

SILICA.

Rem. and Cond.—On adding an excess of mineral acid to a solution containing a silicate, free silicic acid containing indefinite amounts of water is formed, partially or entirely soluble. On evaporation H_2O (of constitution) is removed and insoluble SiO_2 is separated, which may be filtered off after digestion with diluted acid. HCl is the acid most frequently used. When HNO_3 is used, regard must be had to the fact that certain nitrates ($\text{Fe}_2(\text{NO}_3)_6$, etc.) are decomposed at the temperature usually employed to drive out the last portions of the water (110 to 130°C.), and are not readily re-formed by digestion with diluted HNO_3 . The heat is usually maintained until there is no perceptible odor of acid. With H_2SO_4 , the heat is continued until fumes of SO_3 are evolved, indicating that H_2SO_4 is the only free acid remaining. If the heat has not been sufficiently prolonged or intense, the separated silica may be flocculent and filters with difficulty, or some may remain soluble.

If the heat has been too high, the conditions may have favored a re-combination of silica with the bases, and consequent soluble silica (analogous to the action by fusion). The temperature which can safely be applied may be put at 110° to 120° .

According to Gilbert (*Techn. Quarterly*, February, 1890), when only Ca and alkalis are present, the temperature of drying may be carried up to 280°C. without detriment, but if Mg is present, re-combination of the bases with the silica is best prevented by drying at 120°C. Some alumina almost invariably remains with the silica if Al is present in the solution.

Sol.—Dissolved by boiling or fusing with fixed alkalis, caustic or carbonated. Insoluble in water and acids (HFl excepted).

Contam.—Insoluble sulphates (PbSO_4 , BaSO_4) removed by digestion with conc. H_2SO_4 , and filtering through asbestos. (For other solvents of these substances, *vid. sup.*) In some cases

CaSO_4 , removable by digestion with HCl and NH_4Cl . The precipitate may also contain a form of $\text{Fe}_2(\text{SO}_4)_3$ (when separated from conc. H_2SO_4) which dissolves in dilute H_2SO_4 with some difficulty, but is readily soluble in HCl .

SnO_2 or Sb_2O_3 may be retained, as well as TiO_2 (possibly combined with P_2O_5) and ferric or aluminic oxides or basic salts. TiO_2 tends to hold P_2O_5 , Al_2O_3 and Fe_2O_3 in the precipitate. To avoid error in such cases, the SiO_2 should be determined by loss, adding HF or NH_4F (and in any case H_2SO_4) igniting off SiF_4 and weighing again. This treatment is advisable whenever Al_2O_3 is present in the solution in any quantity.

Ign.—Precipitate is very light and fine, and readily carried off by flame, requiring especial precaution on igniting. After ignition, the precipitate will absorb appreciable amounts of water if exposed to air containing moisture.

QUARTATION AND WEIGHING.

BY HERBERT R. WOOD, FELLOW TORONTO UNIVERSITY.

IN making an assay for gold, two half assay tons are usually taken, as the amount obtained from half an assay ton is frequently so small that it is impracticable to weigh. The beads should be removed from the cupels with a small pair of forceps, such as jewellers use, placed on the stand or support, again picked up with the flat surface, squeezed, the hand turned over, and the bead brushed free from bone-ash with a tooth or nail brush held in the left hand. The bead should now be placed down, and again gripped with the pincers at right angles to previous position, again brushed, and placed in a cavity in the small iron slab. (These slabs are one-half inch in thickness, two inches long, one and one-half inches wide, with twelve semi-circular cavities on one surface.)

The beads are then carefully weighed in an ordinary bead-balance.

If there is a number of assays to be made, the beads, when brushed and cleaned, should be placed in the cavities in the slab

according to some arranged system. Thus, twelve assays or twelve crucibles, each holding a half ton, make six distinct assays of a ton each. When placed in the furnace, the crucibles are put in such a position that the highest number comes first, the crucibles having been placed on a board measuring twelve by eighteen inches or thereabouts, numbered in parallel rows, beginning with one, in the lower right-hand corner, and running from right to left, terminating in the upper left-hand corner. The crucibles are arranged on this board, and placed, as above-mentioned, in the furnace, the highest number first, and withdrawn, poured and cupelled in the same order. The beads, when removed from cupels and cleaned, are placed in the slab, the same order being adhered to.

The assayer, when once familiar with this method of identifying his assays, need never fear an error through mixing or confusing them. It also saves much time and labor.

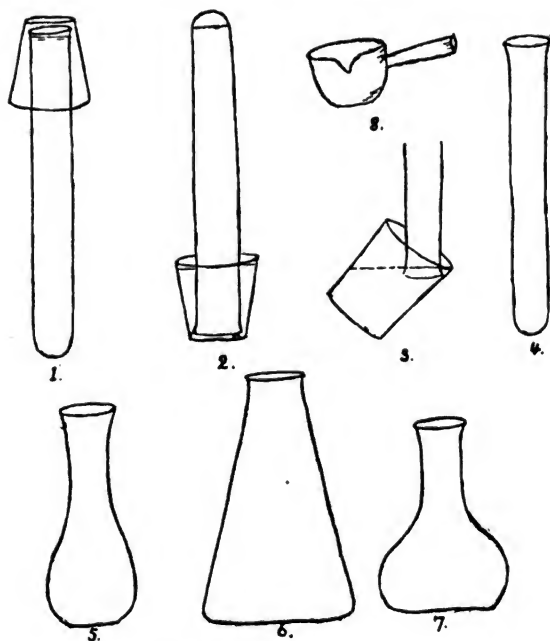
When a number of gold determinations are to be made, the requisite number of test-tubes are placed in a stand. The holes in the support of the stand should be large enough to permit of the tube being thrust in from underneath when reversed, as in Fig. 2. An inch or half-inch of dilute nitric acid should then be poured into each tube and heated to boiling. The beads are then picked up with the pincers, and carefully allowed to slide down the inside of the tube held inclined in the left hand to the acid within. They are usually quickly dissolved, allowed to stand till complete solution of the silver present has taken place, and the particles of gold, if present, allowed to settle to the bottom of the tube. By holding the tube up to the light, a practiced eye can pretty nearly judge the amount of gold present. The vessels which are used for solution may vary in size and shape according to the size of the bead and the amount of gold present, or the inclination of the assayer.

In making silver brick, the large amount of silver and gold present necessitate considerable acid and a shallow vessel, which permits of being placed on a sand bath over a slow heat. In assaying the bullion beads, which, according to the richness of the metal, vary in the amount of gold and silver present, a larger vessel than a test-tube is required. The smaller flask may then be used.

In heating the tubes a low flame is required. If solution does not proceed quickly or is not complete, a tube can be taken in

each hand, moved back and forth over the flame. Allow the particles of gold to settle, then shake them together by twirling the tube and gently tapping it with the finger. Now place the tube on the back of the left hand, so that the gold may be clearly visible, and gradually incline and pour off the acid into a jar for that purpose kept in the sink. About the same quantity of water, or a little more, is added, heated, and carefully decanted in the same manner. This is to entirely remove any traces of acid remaining. The tube is now filled with distilled water from a wash-bottle, an annealing-cup placed on top (Fig. 1), then, by placing the forefinger on the bottom of the cup, the whole quickly reversed, and the cup immediately filled with distilled water from the wash-bottle. If this is not done at once, the water will sink rapidly down in the tube, and particles of gold may be left adhering to its sides. Now place the tube and cup in the rack-stand, which should be at the edge of the table, by thrusting up the inverted end through a hole in the support (Fig. 2). The tube should now be allowed to stand some time till all the gold is thoroughly settled in the cup, at the same time gently tapping the sides of the tube to insure this. Then carefully remove from the stand, holding the cup in the left hand and the tube in the right. Now incline the cup, holding the tube upright till it is drawn to sides of the cup and surface of the water, holding all over the sink. Then, by a quick, dexterous movement, slide out the tube (Fig. 3). This should be done without disturbing the gold in the cup. It is very necessary that the cup should be filled with water. Now carefully tap the cup to bring the scattered particles of gold in a lump, and then decant. Place the cover on and stand before the open muffle door on hearth till dry, then insert with cupel tongs a few inches into the muffle, which should be at a cherry-red heat, till the cover is slightly reddish; then remove, allow to cool, and weigh on Troenmer. If the quantity of gold present be very small, practice will enable the assayer to judge pretty accurately the amount; thus, under six one-hundredths need not be weighed. The gold should be heated until it becomes yellow, being careful at the same time not to fuse it.

Figs. 1, 2, 3 represent the transference of the gold to the annealing cup. Figs. 4, 5, 6, 7, 8 represent the different quartation dishes, on the respective advantages of which the following comments are made.



4. This tube measures one-half inch by five inches. This is a convenient size, but larger may frequently be found useful.

5. A test-tube blown out at one end. It answers for larger beads.

6. Small Florence flask, used when making silver brick for gold.

7. Is not so satisfactory as the gold. Is apt to stick in flask. The annealing cups cannot be used here so handily.

8. A casserole, but out of which the gold is apt to spit. Requires great care, and is not to be recommended.

WEIGHING.

In weighing gold the Troenmer's gold balance is the most satisfactory. It will weigh satisfactorily to .04 and quantities below

this the assayer can call a trace. This balance has an agate edge at the centre and double pillar support which makes it very strong. It also possesses a very delicate adjustment ball which must be very carefully used—one arm only, *i.e.*, the right, is graduated for a rider. Before using the balance should be carefully adjusted, the pans dusted with a camel-hair brush, as frequently slight differences in weight are thus remedied. The operator should sit squarely before his balance and use his left hand in turning the screw, the right for manipulating the weights. The pans should never be touched by the fingers, but always lifted with pincers, an ivory-tipped pair being the best. In placing weights on the pan care should be taken that the pincers do not scratch the metal. In fact, it is better to lift the pan entirely free from the balance and empty the weights on the case. To remove the gold from the annealing cup, a round-pointed blade of a penknife is used. This will detach the particles which, if properly manipulated in the furnace, will be agglutinated. The gold annealing cup is inclined over the pan and gently tapped with the knife, then reversed and very carefully scraped around, care being taken that no particles of clay are mixed with the gold. If such are present they may be gently blown out or picked out with the pincers. The cup is again decanted and tapped. The finger is then rubbed around in the cup and examined in the sunlight to see if any particles of gold not removed to the pan adhere to the finger. In examining the cup the breath must not be allowed to interfere. In weighing, a little practice will enable the operator to work quite rapidly. When the pan containing the gold is replaced the rider is moved midway of the beam with the right hand, the other turning the screw very gently down till the support leaves the beam. If the needle oscillates to the right the rider is moved toward the end of the beam till correct weight is obtained. Care should be taken that the support is not raised while the needle is oscillating, but when it has reached the middle index, so that no unnecessary jar takes place. The weights, which are milligramme weights, should be kept in the centre of the case, resting against the foot of the upright supports, so that they may be readily reached. The gold should then be brushed out into some receptacle and the pan replaced. No moisture should be on the hands or tools in working with this balance. As a very slight jar, the walking of some one, will prevent the needle from coming to rest, it is advisable to have the balance placed on a very firm foundation.

GRAPHIC FIELD NOTES FOR RECONNOISSANCE SURVEYING AND AREAL GEOLOGY.

By BAILEY WILLIS.

(Read before the Geological Society of America, December 30, 1890.)

IMPORTANCE OF RELATIONS IN SPACE TO GEOLOGIC STUDIES.

SOME years ago a coal property in Washington territory was offered for sale by shrewd speculators, who valued the land at \$1100 an acre on account of the great thickness of workable coal said to occur in several veins. The property was not developed, but the number of coal-beds and a total thickness of good coal of more than one hundred feet were confidently stated from exposures of the folded coal measures in a cañon 400 feet deep, which traversed a plateau whereon glacial drift and primeval forest obscured the strata. Of these natural conditions the speculators skilfully took advantage; they opened the coal-beds on the cañon sides at points which were not intervisible, and they cut a labyrinth of paths through the forest leading from one opening to another. On the cliffs these paths were unpleasantly narrow; in the underbrush of the plateau they wound about in such manner as to exaggerate the impression of distance. It was shrewdly calculated that any geologist by these means topographically misled might be geologically confused and led to count a single coal-bed seen at different openings as several beds. And this calculation was justified by the result. An expert of high standing, whose experience and reputation fairly commanded confidence, reported the coal at nearly three times its actual thickness, and \$750,000 was paid on his mistake. The error in stratigraphy followed from ignorance of the local geologic structure, both avoidable had the geologist determined relations of distance and direction among observed sections.

The point of this story is the point of this article: A knowledge of relations in space among geologic facts is essential to the solution of problems of stratigraphy and structure, and it follows that the geologist must locate his observations on a map either prepared in advance or surveyed simultaneously with his work. The

possession of an adequate map constitutes the ideal initial condition for geologic work.

DEFINITION OF AN ADEQUATE MAP FOR GEOLOGIC PURPOSES.

General Definition.—An "adequate map" is one which faithfully describes the character of the features delineated; it is so characteristically true to the facts of relief, drainage and culture that cartographic details can be identified with natural features; it offers many tie-points, *i.e.*, many points which can be definitely recognized as the representatives of specific locations on the ground. Such points are essential to the location of a geologist's observations of outcrops, strikes and dips, or formation boundaries, which may be of very limited extent, but which must be placed on the map with such accuracy that the error, reduced to the scale of the map, is insignificant. Such tie-points are bends of roads, cross-roads, crossings of roads and streams, sharp turns in streams, stream junctions, springs, mountain peaks, ridges, gaps, spurs, abrupt changes of slope; in a word, all characteristic features.

Maps are sketches fitted to a geometric control. If we compare them with works of higher art, we may liken the painfully exact military maps of Europe to miniature portraits, while some American maps, produced under demand for quantity rather than quality, suggest paintings executed with a palette knife. The difference lies in the minuteness of control, in the number of points accurately determined per square inch of map.

Methods of Control.—The measurements which constitute control are obtained by two methods, triangulation and meander, each of which has its advocates, each of which requires certain natural conditions for economic working, but which in most regions can advantageously be combined.

Unsupported triangulation affords few tie-points; stations and intersections are fixed without appreciable error to the scale of the map, but roads, streams, and contours, if the last be employed, are generalized according to the handwriting of the topographer rather than to the character of the topography. The geologist who is obliged to use such a map should be fitted to locate himself by direct reference to the geometric control, and he should check the generalizations of the map by such references.

A meander line fitted to a scheme of triangulation supplies tie-

points within a belt of varying width. If it follows a road or stream each change of direction provides a tie-point, and the elements of relief within the topographer's view are fixed usually beyond his power to generalize out of recognition. Thus the number of tie-points increases much faster than the number of miles of meander run; and the value of the map is rapidly augmented as the network of meander lines is made finer. Thoroughly satisfactory maps can be made by this method. The first example of this class of work which came to my notice was the Greenville, Tennessee, atlas sheet of the U. S. Geological Survey series; it represents a thousand square miles of the valley of Tennessee, where the present relief is a dissected base-level in limestone, overlooked by strike ridges of sandstone and shale. All the roads were meandered, the total distance being about 1200 miles, a season's work for one topographer. The southeastern corner of the sheet is mountainous and without roads. Here the topographer was confined to sketching to fill in his triangulation, and the resulting map is so inadequate that the geologist was obliged to correct the base by meander lines run on foot. Other maps of this desirable character have been and are being made by those topographers who appreciate the possibility of putting character into their work. Such men raise their profession from the dead-level of mechanical generalization to an art which expresses important geographic truths. And those geographic facts are but the latest expression of geologic processes, which it is the province of the geologist to interpret. But the topographic artist has been a rare being, and while we may felicitate ourselves upon the prospect of his becoming more numerous, we still have to work with the inartistic product.

PROCEDURE WITH AN INADEQUATE BASE.

The General Question.—How can the geologist best proceed in the field with a map which does not afford tie-points for his observations? or, in other words, given an inadequate base, what method of field-work leads most satisfactorily to the development of a geologic map? To this question, thus broadly stated, no intelligent answer can be given. Account must be taken of the geologic problem, of the aspect of its presentation, and of the characteristics of the geologist. The student of crystalline rocks, accustomed, perhaps, to the limited outlook in a Michigan forest, cannot well

devise details of methods for him who studies stratigraphy and structure on the treeless plains of the West. Nor can he whose stratigraphic work in the settled States is facilitated by roads prescribe methods for the investigator of volcanic geology in uninhabited mountain ranges. Each must adapt to his own environment the means of recording and arranging observations, but he will certainly do so more intelligently if he avails himself of the experience of others whose training and experiments may contain positive or negative suggestions.

Believing this, I propose to give here, for what it is worth, the experience of the Appalachian division of the United States Geological Survey with graphic methods of mapping formations.

Appalachian Work in the U. S. Geological Survey.—The Appalachian Paleozoic province presents stratigraphic and structural problems under an aspect which is familiar to all of us. Relief is seldom emphatic, heights have usually struck an average elevation through successive base-leveling, soil covering is the rule, vegetation flourishes everywhere, and cultivation assists in obscuring geologic facts; these are obstacles to rapid work, whatever the problem. On the other hand, relief and structure are intimately related as effect and cause, the factors of the problems, multitudinous as they often are, are crowded together in small space, every part of the region is easily accessible, roads and houses permit facilities not else available; these are aids to successful work.

The geologists of the United States survey who entered this province prior to 1886 were trained in western fields and did not at first devise the best methods of work. The amount of geology per square mile was embarrassing to them; the facilities afforded by culture were not appreciated. It seemed, moreover, a fair assumption that the Rogers brothers, Safford, and others had solved the geologic problems of the region and that to resurvey their fields was but to confirm their results, which must be done in detail and with great accuracy. Triangulation for detail was forbidden by the absence of marked features of relief or culture, and meander methods were a necessity in the absence of adequate maps.

Stadia Transit Method.—The special conditions and the fact that the purpose of the work was section-measurement led to the selection of a very accurate method based on stadia measurements of distances. The instrument used was a light transit, mounted

on tripod and leveling screws, carrying a telescope with a vertical limb and fixed stadia wires. The stadia rod was 12 feet long and graduated by experimenting with a base measured by a steel tape; there were two movable targets, which were adjusted by the rodman on signals from the surveyor until the interval between them was proportioned to the space between the stadia wires of the telescope; the number of divisions on the rod included between the targets then corresponded to the distance from transit to rod. The maximum distance measurable with this instrument and rod was 1500 feet. A much greater reach might have been obtained with a longer rod, but it was not deemed desirable.

The operation at any one station was as follows: the geologist set up and leveled his transit, received from the rodman the distance reading of the last sight and platted his topographical and geological notes accordingly. The rodman set a target to the height of instrument and went on to select the next station. When ready the rodman called, the geologist observed and noted the course and slope of the new sight, by signals adjusted the targets to the stadia wires, and then rejoined the rodman.

By repetitions of this process, with more or less delay for misunderstandings on account of the distance frequently separating the geologist and rodman, the meander line progressed at the rate of three to six miles a day.

The record consisted of two parts containing similar information: the one part composed of figures and verbal notes; the other part representing approximately the map to be platted from these figures. The final interpretation of the whole record constituted the office work.

This required for each sight the reduction of slope distance to its horizontal projection and a calculation of elevation of each station. The course and distance being platted, the geologic facts could be indicated and the sections developed. This labor proved very onerous; unnecessary mechanical accuracy of delineation absorbed time that should have been given to thoughtful study. The end in no sense justified the means, for the method was adapted to the accurate co-ordination of a mass of facts in a small area, as in a mining survey, not to generalizations in stratigraphy and structure.

Adoption of Graphic Methods.—It has already been stated that the record of stadia work was in two forms: the one numerical,

the other graphic. The former occasioned most of the office work, the latter contained the pith of the geologic information. It followed that in casting about to devise a method for mapping formations, we sought to get rid of the figures and to improve the sketch to the standard required for a final plat fit for transfer to the map. To do this required the adoption of some means other than the stadia of measuring distances, and of means for sketching directions and distances more accurately than had previously been done.

For measuring, two instruments have been successfully used; the one the wheel of a buckboard or sulky with some attachment for marking its revolutions; the other a pair of legs, usually those owned by the geologist. With the former the unit of measurement is a "wheel," *i.e.*, the circumference of the wagon wheel; with the latter the unit is a pace, a function of the individual. These vary in different instruments and require reduction to a common scale before combining different pieces of work.

Measurement with a wheel is an old method, improved within the last few years to meet the demand of the topographic division of the United States Geological Survey for an efficient means of traverse work. Mr. Henry Gannett says of it:

"As nearly all traversing is done along roads, distances are measured in this work mainly by counting the revolutions of a wheel—usually one of the wheels of a buggy or buckboard. Various forms of odometer for automatic counting have been in use. The old pendulum odometer was first tried and unqualifiedly condemned. The form now in general use is that devised by Mr. E. M. Douglas, of this Survey. For working this a cam is placed on the inside of the hub, which, by raising a straight steel spring, carries the index forward one division for each revolution of the wheel. The odometer registers to ten thousand. This form is the most trustworthy that has yet been devised, but is not altogether satisfactory, and the majority of traverse men prefer to count the revolutions of a wheel directly. The arrangement by which a bell is rung at each revolution is a very common and effective device. From an extended experience covering many thousands of miles of measurements it has been demonstrated that as a working method of measuring distances the wheel is greatly superior upon roads to the stadia. Moreover, it is nearly if not quite twice as rapid as the stadia method."*

* Unpublished MSS.

The attachment of the Douglas odometer to the wheel varies with the ingenuity of individual users: it may be placed on either axle, when its connection with the wheel is then most direct; or it may be placed beside the seat of the vehicle and connected with the wheel by wires working a system of levers. The latter arrangement requires nice adjustment but raises the odometer out of the reach of mud, places it within convenient observation and enables the observer to judge the regularity of its register by the click of the ratchet.

Pacing, as a means of measuring short spaces, we are all familiar with; but pacing mile after mile, day after day, for continuous record is not a common practice. It was only after experience had demonstrated both the necessity and practicability of pacing that I gave the method practical consideration. Where the wheel can be driven it has the advantage; but where the wheel must stop, the pace becomes a convenient and indeed indispensable unit of measure, which never fails one who has practiced it. It may be confidently stated from repeated experiences that there is no condition of surface, of slope, or of obstruction, over or through which a man cannot pace, with a reasonable approximation to the true distances, provided the ends of the meander line are so tied to some control that the scale of the meander plat can be independently determined. Systematic pacing for geologic record was first used by the Canadian Survey and in the United States by Brooks and Pumpelly in the Lake Superior region. The United States Land Survey there divided the country into square miles and within these north or south straight lines were paced at regular intervals. The accuracy of the pacer was checked at each section line, and woodsmen selected for the work became very expert, keeping count of regular steps through underbrush, through wind-falls, and even in deep snow on snow-shoes. It was found expedient to adopt an arbitrary pace, 2000 to the mile, and outcrops were located as so many west and so many north from the southeastern corner of any particular section. Where the notes of different observers were to be studied by one geologist a uniform pace was desirable, and it is probable that the short pace, 2000 to the mile, is a more regular unit of measure than a longer stride; for, being shorter than a man's average step, it would be less affected by the varying conditions of the ground; certainly no one who attempts to stride beyond his ordinary step can pace regularly

for any long distance. Yet few men care to train themselves to a definite short step, and it is not necessary where the distances paced are at once recorded in a plat of known scale, since the unit of measurement then becomes a matter of indifference. It is only necessary that the pacer should know and record his average step, and this can be ascertained by counting paces for half a day in walking a known distance or by platting a day's route to an assumed scale and correcting it by a map of known scale.

The principal difficulty in pacing is to keep a correct count of steps, and to avoid this we have found it desirable to count every fourth step only, while yet giving to each footfall a digit or number. The mind readily recognizes a certain rhythm or time-beat on the fourth step, and it will unconsciously repeat the total number of paces in time with successive steps, adding one for each completed pace of four steps. Thus, starting out the left foot first, the rhythm runs: Left, right, left, one, or 0, 0, 0, 1, 0, 0, 0, 2, etc.; and further on, left, right, thirty, five, or 0, 0, 3, 5; still further, left, four, fifty, two, or 0, 4, 5, 2; when more than a thousand paces are numbered, one, three, seventy, eight, or 1, 3, 7, 8; the next pace, 1, 3, 7, 9; then, 1, 3, 8, 0; and 1, 3, 8, 1, etc. Thus, each step repeats the appropriate figure, and the four together give the total number of paces; the units change with every fourth step, the tens only with every fortieth step, and the hundreds and thousands each in their degree with less frequency. The repetition, unconscious though it comes to be, fixes the total number beyond the possibility of loss.*

The means of measurement being adopted, the method of recording is the next step; of these there are two: the plat on the traverse plane-table and the plat in the note-book.

The traverse-table was devised by Mr. Gannett for the purpose its name indicates. He describes it as follows:

"The plane-table used for traversing is of the simplest possible

* These methods of measurement suffice for the geologist on wheels or on foot, but they fail him on horseback. In discussing this paper Dr. G. M. Dawson described a method of "time survey," which consists in riding a horse at a steady walk, and noting the exact time consumed in riding over each course. The time-unit of the plat is a function of the *gait* of the horse, and is influenced by variations of the latter, and errors may creep in through disregard of momentary halts; every check should be noted. But when carefully watched the time-survey is accurate to about one-fortieth of the distance. Dr. Dawson also referred to experience with a boat-log in lake surveys.

form, consisting of a board 15 inches square, into one edge of which is set a narrow box containing a compass-needle 3 inches in length. The table is supported by a tripod of light construction, without levelling apparatus, the level of the instrument being effected by the legs of the tripod. The table is adjusted in azimuth or oriented by means of the compass-needle, movement in azimuth being provided by simply turning the table on top of the tripod head. There is no clamp to the azimuth movement, the table being held in place simply by friction. The alidade consists of a brass rule 12 inches long, with raised sights hinged to turn down when not in use. Ordinary drawing-paper backed with cloth is used for plane-table sheets, and is attached to the board by thumb-tacks." *

The operation of traversing with this instrument is very simple. At each station the table is oriented by bringing the compass-needle to a mark on its short scale; the area of the map is usually too small to show any convergence of magnetic meridians, and if the magnetic declination be constant, it follows that at each station the position of the table is parallel to all those preceding it. Courses sighted and drawn with the alidade, whether successive foresights or alternating foresights and backsights, therefore depart from each other with angles equal to those included by the directions on the ground, and the lengths of the sights being laid off to scale, the plat is a figure mathematically similar to the traverse on the ground. On this plat geologic observations can at any instant be indicated in their proper relations. It is customary to foresight to bend of road, tree, fence-corner or any other distinct object, to wheel or pace to the thing sighted, thence to wheel or pace to a convenient station and set up the table. At this station the operations are: (1) to orient the table, (2) to scale off the first foresight, (3) to sight and draw the backsight and scale it off, (4) to sight and draw the next foresight, (5) to sketch in topography or geology, and then to proceed. Time is economized by occupying alternate stations only, and geologic relations are developed as fast as the traverse-line is extended. I believe that this simple instrument will prove to be of great value to geologists, and will save time, labor and money in the extensive work of geological mapping.

But notwithstanding the simplicity and accuracy of the traverse-

* Unpublished MSS.

table, geologists who do not wish to carry a mounted instrument of any kind have tried to accomplish the same object with only hand-compass and note-book. To do this is to reduce instrumental impedimenta to a minimum, but the observation and recording of the traverse requires more care than on the plane-table. Given an ordinary clinometer compass with square base and sights and a note-book ruled in squares, the operation at any station is as follows: (1) to foresight by holding the compass in the right hand or on the note-book at half arm's length and at a convenient height for alignment with the object sighted and for reading the course; the compass sights may be closed or raised for this alignment and additional accuracy is perhaps obtained by sighting the longer side of the note-book placed parallel to the compass sights; (2) to record the foresight by drawing a line on the note-book page at the observed angle from a meridian previously assumed; a small horn protractor is useful for this purpose, but it is only necessary for long sights, such as those taken to locate distant points by intersections. It is easily possible to estimate the angle of the observed course with sufficient accuracy for sights of a quarter of a mile or less by bearing in mind the angles made by the diagonals of various parallelograms; thus the diagonal of a square is at 45° , that of a rectangle 2×3 is at 34° and 56° , that of one 1×2 is at 27° and 63° , that of one 2×5 is at 22° and 68° , that of one 1×3 is at 18° and 72° , that of one 1×10 is at 6° and 84° , etc. These diagonals are easily noted on the reticulated page. If a protractor is used it should have one straight side with a scale on it; if there is no protractor a convenient ruler can be made of a page of the note-book torn out and folded parallel to one set of lines; the folded edge will be straight and the lines at right angles to it give the scale. It is obvious that errors of angular notation are more serious the longer the sight laid down; hence more care is needed on long sights or on a large scale than on short sights or on a small scale. The limits of scale which have been found desirable for field platting in the Appalachian field are one and two miles to the inch; the smallest scale on which legible notes can be written is the best. As the meander thus noted is extended, geographic and geologic notes fall into place along it.

Summary of Methods.—In the foregoing paragraphs I have sketched three ways in which members of the Appalachian division keep geologic field notes; first by direct notation on an ade-

quate base, where such is available, second by notation on a meander run with traverse plane table and odometer or pacing measurement, third on a meander surveyed without mounted instruments and platted on the note-book page. It remains to indicate what the use of such methods accomplishes.

In any comparison of methods for the determination of efficiencies, two factors must be considered for each method under like conditions. These are quantity and quality of work. Under the conditions of stratigraphy, structure and culture existing in the Appalachian province, the quantity of work which can be accomplished with graphic methods of keeping field notes is best estimated by stating the number of miles of meander line that, with topographic and geologic notes, can be platted daily. Using the odometer attached to a buckboard with two horses and a driver, we estimate the average product at 15 miles a day after two years' experience. Pacing for the same record averages seven and does not exceed ten miles a day. Our experience further shows that these averages added to the distances from and to lodging places, lunch being taken afield, form a sufficient day's travel for horses or men, when performed day after day throughout the field season. Thus the quantity of product by this method is about equal to the endurance of means of transportation.

Quality, if we consider the work of different men, is a very variable factor; but if we compare the value of graphic notes with that of written notes taken by the same man we shall get a definite result. We find that graphic notes are more concise, more definite, more accurate than verbal notes; graphic notes are more easily understood by a fellow-observer, be he chief or assistant; graphic notes directly present facts in visible relations; words do not; graphic notes are capable of immediate transfer to the base map; verbal notes must first be translated into graphic form. He who takes graphic notes in the field arranges facts, one by one, each in its place and in proper relations to all others; he who takes verbal notes forms a mental image of these relations, often an erroneous one, which must be corrected by a subsequent plat. Moreover, the possession in orderly arrangement of all facts observed up to any point in a piece of work enables the observer to plan ahead and directs his attention to missing links in the chain of evidence. Hence graphic notes, even if more slowly taken than verbal notes, are usually more complete and save waste and repetition of field work.

In the office there can be no question of the saving of time accomplished by graphic methods of field work.

In one instance two adjacent atlas sheets covering 1000 square miles each, which presented structural problems in terms of similar stratigraphic units, were surveyed by a geologist and his assistant; the notes recorded in the one consisted of statements of distances wheeled off on roads and the corresponding geologic facts—a verbal record; the notes taken in the other were all platted directly in the field. Field work for the former was 34 days, for the latter 30 days. Office work for the former consumed four weeks, for the later but two weeks.

The preparation of maps is but routine work, the aim of which is the elucidation and presentation of geologic problems; to reduce the time demanded for routine is to gain time for study and is therefore a step toward improvement in the quality of the final result.

The graphic methods which I have indicated are methods of accurate work; in the Appalachian province they are also methods of detailed work; but this is a condition of special application, not an inherent necessity. Running a meander line facilitates but does not necessitate the observation of geologic facts. Nevertheless it is true that the knowledge that every fact observed can be noted in its proper relations tends toward detailed observation.

The geologist, who is forging a continuous chain of evidence, becomes apprehensive of missing links, and the visible continuity of his record leads him to close observation; he skips nothing. And herein is a reflex action of graphic methods upon the observer, which is one of their best recommendations. The graphic record invites close attention to the accumulating facts; it is suggestive, and directs observation to possible undiscovered facts. Graphic methods make keen observers.

TYPES OF FIELD NOTES.

Verbal Descriptive Notes.—Example :

Above these beds of Clinton ore, which lie in yellowish shales, is a white sandstone, forming the summit of Walden's ridge, and its southern slope to the fault on the south. This sandstone is precisely like that observed on Poor valley ridge, Cumberland mountain, but it here lies above Clinton ores, and there it underlies them. At the summit of Walden's ridge this sandstone and the Clinton shales with ore are folded in a sharp broken anticlinal and gentle synclinal, which restores the southern dip; this structure is well exposed in the sandstone cliff.

This form of record is often imperatively necessary to supply descriptions of relations or of physical characteristics of rocks which cannot easily be graphically expressed. The description written on the spot has an authority and value no subsequent statement can have, and the verbal form permits comparison of facts, as the graphic form does not in the same degree.

Verbal Notes for Stratigraphy.—Example :

Descending Cumberland mountain at White Rocks. Dip of strata 15° to 20° north-westward; aneroid 2740 feet. The summit and escarpment of the mountain are formed of fine-grained sandstones, cross-stratified, and containing layers of quartz pebbles 1 inch and less in diameter

715 feet (aneroid) below the summit the sandstone talus covers a light-greenish shale; aneroid 2025 feet.

Outcrop of yellowish sandstone below shale; aneroid 1850 feet.

Highest outcrop of compact gray limestone; aneroid 1780 feet.

Highest outcrop of purple shales; aneroid 1720 feet.

Such aneroid notes are of value for determinations of thickness of strata where the beds lie flat, or at a gentle dip, and the observations can be made on a steep slope; that is, where the vertical measurement is of principal value, and the relations in horizontal plan are not essential to the result desired. Again, given an adequate contour map and a simple problem of stratigraphy and structure, such notes may answer for the location of boundaries and structural facts, but their value is in proportion to the accuracy of the map and the simplicity of the problem, so that they may at any point become valueless through inaccuracies of the one or through unexpected complications of the other.

Verbal Notes for Horizontal Location.—Example :

Went from camp $1\frac{1}{2}$ miles \pm along river bank; no outcrops. Turned up south-eastward, ascending crooked ridge; in $\frac{1}{2}$ mile \pm came to outcrop of typical quartzite.

Followed along the strike, descending to brook; section well exposed. Up brook, course S. 10° \pm W., pass over alternating beds of sandy shale and sandstone, dips varying from 10° to 85° ; in $\frac{3}{4}$ mile \pm heavy sandstone, may represent typical quartzite; in fifty steps fossiliferous limestone, either under or over quartzite, dips 70° to 90° , structure indeterminate. Collected fossils and returned to camp.

This represents a bad case; careless work from the start vitiated the value of any possible observation. On the face of the note it is apparent that the approximate distances are not worth anything,

and when the looked-for quartzite was found its existence was established but not its position. The geologist, having observed nothing up to this point, was practically lost; and being lost, that is, being cognizant only of general relations, he disregarded the details of the brook section. This day's work resulted in a collection of fossils from a limestone which was topographically and geologically undetermined, and was consequently almost wasted. This ineffectual result followed from a loose beginning; it may serve to point the application of the old saying: "Whatever is worth doing at all is worth doing well."

Graphic Notes.—An example of graphic field notes, taken directly from a field plat drawn in the note-book without the use of a protractor, is illustrated in the accompanying plate. The original record is in pencil; a tracing in ink was made, the character of the original being maintained as closely as possible, and this tracing reproduced by photo-engraving forms the plate.

ABSTRACTS.

ANALYTICAL CHEMISTRY, BY E. WALLER, PH.D.

Hints to Beginners in Iron Analysis. Browne (*Jour. Anal. and App. Chem.*, v. 325) gives a number of useful and practical suggestions as to plan of laboratory, apparatus and chemicals for those starting a laboratory at an iron works. The original paper should be consulted.

Bromic Acid as a Reagent. Feit and Kubierschky (*Chem. Ztg.*, xv., 351) recommend this reagent, especially in volumetric work, on account of its great oxidizing power and because it readily liberates a definite quantity of iodine from KI. In practice, the reagent is prepared by dissolving 30 gms. of KBrO_3 in 300 c.c. of water, and boiling with dilute H_2SO_4 to decompose any HBr present, then cooling and diluting to one litre.

New Alkalimetric Indicator. Mylius and Foerster (*Berichte*, xxiv., 1482) find that the sodium salt of erythrosin (iod-eosin), after purification, is poor as an indicator when used in the ordinary manner, but if some ether is added, it constitutes an exceedingly sensitive indicator. Place 50 to 100 c.c. of liquid to be titrated in a stoppered flask, and add 10 to 20 c.c. of an ether solution of erythrosin compound containing 0.002 gm. per litre. If the solution is alkaline, it assumes a rose tint. When it is acid the aqueous solution becomes colorless. Titrations with thousandth normal solutions can be made by this means. The indicator is indifferent to CO_2 , and unsatisfactory with oxalic or organic acids. It is neutral to neutral salts of Mg, Cd, Zn, Mn, Ni and Co, but gives the acid reaction with those of Fe, Al and Cr. With Pb and Ag it is unsatisfactory.

Alkalimetric Indicators. Foerster (*Fres. Zts. Anal. Chem.*, xxx. 304) prefers naphthol green to malachite green, in conjunction with (purified) lakmoid. He recommends to make a solution of 3 gms. purified lakmoid and 5 gms. naphthol green in a mixture of 700 c.c. water and 300 c.c. alcohol. Zaloziecki (*Ib.*, p. 333) describes the preparation and use of alpha naphtholbenzein. With alkalis it gives an intense green, with acids red-yellow. It is quite sensitive to carbonic acid. A one per cent. alcoholic solution is the best for use.

Barium Sulphate. Mar (*Am. Jour. Sci.*, xli.) reports some experiments on the analytical relations of this salt. He finds that considerable quantities of HCl in the solution do not have the solvent effect usually ascribed to them; also, that the presence of HCl does not prevent to any great extent the contamination of the precipitate by alkaline salts. The method of purification by dissolving in concentrated H_2SO_4 and pouring into water was not found to operate satisfactorily; but on evaporating the H_2SO_4 solution of the precipitate to dryness, and then

washing, the BaSO_4 was obtained fairly free from contaminant. By the aid of a Hempel burner (*Berichte*, xxi., 900) the evaporation was rapidly effected.

Titration of Alumina. Cross and Bevan (*J. S. C.*, I, x., 202) reiterate a statement made some time ago (*vide* QUARTERLY, x., 371), that on titrating an aluminate with methyl orange as indicator, the neutral point is reached when the ratio is $2\text{Al}_2\text{O}_3$ to 5SO_3 , instead of to 6SO_3 , as stated by Lunge. The latter replies (*Ibid.*, x., 314) with an account of fresh experiments which appear to prove his contention. He suggests that the change in color of the indicator takes place slowly towards the last in solutions of ordinary temperatures, but very promptly at 40°C .

Ferrocyanide Titration of Zinc. Moldenhauer (*Chem. Zeit.*, No. 14, 1891) finds that Mg and Mn interfere. By treating the solution with a little Na_2HPO_4 and excess of ammonia, he precipitates those out, and then titrates the Zn. His method is: Dissolve 2.5 grms. ore in HCl, with a little HNO_3 , and dilute to 250 c.c. Mix 25 c.c. of the solution with 10 c.c. of ammonia, and titrate to get an approximate idea of the amount of Zn present. To 50 c.c. of the solution of the ore add 10 c.c. ammonia and 5 c.c. of a solution containing 5 grms. ammonium carbonate, 5 grms. NH_4Cl , 10 c.c. of ammonia and 90 c.c. of water, warm, to settle the precipitate; cool, and add 2 c.c. of a 10 per cent. solution of Na_2HPO_4 , which will precipitate Mg and Mn as phosphates. Titrate this solution, which will give the correct result.

Volumetric for Manganese. Blum (*Fres. Zts. Anal. Chem.*, xxx., 284) proposes titration with ferrocyanide in an ammoniacal solution containing tartaric acid and NH_4Cl . Some ferric salts should also be present. The end reaction is when a drop of the solution shows blue with a drop of acetic acid, showing an excess of ferrocyanide. The precipitate is $\text{Mn}(\text{NH}_4)_2\text{FeCy}_6$. The solution contains 38,487 grms. cryst. K_4FeCy_6 . 1 c.c. = 0.005 gm. Mn. Dissolve 5 grms. of mineral in concentrated HCl, rinse (without filtering) into a 250 c.c. flask, fill to the mark, mix, and take portions of 50 c.c. at a time. If not enough Fe is present, add a little Fe_2Cl_6 . Add 20 c.c. cold saturated NH_4Cl solution, 30 c.c. tartaric acid solution (1 : 2) and a large excess of ammonia. Titrate boiling.

Manganese Titration by the Volhard Method. Blum (*Fres. Zts. Anal. Chem.*, xxx., 210) criticizes Rürup's method of managing the titration, in which Na_2SO_4 solution is added, and refers to Meinecke's experiments, which go to show that an excess of ZnSO_4 and absence of ZnO are essential features for accuracy. A neglect to allow for the volume of ferric hydrate separated by the ZnO may also be a source of error.

Determining Manganese. J. and H. S. Pattinson (*J. S. C. I.*, x., 333.) Dissolve an amount of the sample containing not over 0.25 gm. Mn in HCl. If ferrous iron is present in the solution (spiegel, etc.), add HNO_3 sufficient to oxidize to ferric. If the amount of Fe is less than that of the Mn, add sufficient Fe_2Cl_6 to make the proportions about equal. An excess of Fe does no harm. Just neutralize the solution with CaCO_3 ,

and then render it slightly acid with HCl, so as to just remove the deep red tint. Then add 30 c.c. of ZnCl_2 , containing 0.5 gm. of the metal, and dilute to about 300 c.c. Dissolve about 33 gms. of a 35 per cent. bleaching powder in one liter, and filter. Of this solution take 60 c.c., add to it enough HCl to give it a faint permanent greenish-yellow color, and add to the solution from the substance under examination. Finally, add about 3 gms. CaCO_3 diffused in 15 c.c. of boiling water, after the first evolution of CO_2 , and, stirring, add 2 c.c. methylated spirit, and stir. Filter, wash first with cold water, then with warm (65°C.) until the washings have no effect on KI and starch. Dissolve the precipitate in a known amount (70 c.c.) of standardized FeSO_4 , containing free H_2SO_4 (1 to 3), and titrate cold with $\text{K}_2\text{Cr}_2\text{O}_7$ solution. The oxidizing power of the precipitate being thus determined, it is calculated as MnO_2 . Bromine water may be used in place of the bleaching powder solution. The strength should be about 22 gms. per liter; of this 90 c.c. should be used for about 0.25 gm. of Mn. Co and Cr. interfere somewhat with this method. Pb, Cu and Ni also interfere slightly, but to a less extent than Co and Cr.

Separation and Determination of Nickel and Cobalt. Krauss (*Fres. Zts. Anal. Chem.*, xxx., 227) gives a critical review of the various methods proposed by different chemists, with brief accounts of his experiences. For details, the original paper must be consulted. In closing, he remarks that some phenomena which he has observed seem to favor the view of Krüss and Schmidt as to the existence of another element accompanying cobalt and nickel.

Chromium in Steel. Hogg (*J. S. C. I.*, x, 340) proposes a colorimetric method depending upon the depth of tint imparted to the H_2SO_4 solution of the steel. As standards one must use solutions from steels containing known amounts of Cr. A 2 per cent. standard will serve for all percentages between 1 and 4. For lower percentages a 1 per cent. standard may be made to serve by adding known amounts of pure iron.

Decomposition of Chromite by the electric current. Smith (*Am. Chem. Jour.*, xiii., 414), conducts the operation in a nickel crucible which forms the anode, in which 30 to 40 gms. KOH are kept in fusion. 0.1 to 0.5 gm. of the powdered chromite is brushed from a watch glass into the surface of the melt. A platinum cathode is inserted, and the crucible covered; complete decomposition usually seems to result in 15 minutes, but for safety 30 to 40 minutes is recommended. Before interrupting the current, it is well to reverse it by means of a commutator in circuit. The current should not exceed one ampere. The iron is deposited on the platinum cathode, while the melt contains the chromium as chromate. Cool, dissolve in water, filter, and determine gravimetrically or volumetrically.

Separation of Titanium. Haas (*Fres. Zts. Anal. Chem.*,) reports the results of investigations on the subject, the method used being the heating of mixed oxides in a tube of hard glass through which a current of hydrogen is passed. Titanic oxide is not rendered soluble by this means, whereas tin or iron are reduced to the metallic state, and can be ex-

tracted by dilute HCl. The remaining TiO_2 may be rendered soluble by fusion, with bisulphate, or better by fusion with K_2CO_3 . SiO_2 if present, should be removed by HFl, previous to the hydrogen treatment.

Separation of Manganese and Zinc. Jaunasch and McGregory (*J. Prakt. Chem. N. F.*, xliii., 402) have experimented on the use of H_2O_2 in an ammoniacal solution. They find that unless the solution contains large amounts of NH_4Cl and ammonia the separated MnO_2 will carry with it some zinc. Where enough of those reagents is used, the separation is complete.

Separation of Iron from Cobalt and Nickel. Le Roy (*Comptes Rend.*, cxii., 722). The solution of the metals in the form of sulphates, receives the addition of a little citric acid, and then a large excess of solution of $(\text{NH}_4)_2\text{SO}_4$ containing free ammonia. The electrodes of a battery affording 300 c. c. of gas per hour) are then introduced. Manganese if present is deposited on the + electrode as MnO_2 , the other metals in metallic form on the — electrode. When this deposition is complete, the — electrode is removed from the solution, and after washing is made the + electrode in a concentrated solution of pure $(\text{NH}_4)_2\text{SO}_4$ supersaturated with ammonia. (The current should be of a strength to give 100 c. c. of gas per hour). The Ni and Co, are transferred by the current to the — electrode, while the iron assumes the form of ferric hydrate suspended in the solution. When filtered off it is found to be from Co or Ni.

Iron and Alumina in Phosphates. Shepherd (*Chem. News*, lxiii., 251) gives a modification of Glaser's process (*vide* QUARTERLY, xi., 273), using HCl only as the solvent, and using less H_2SO_4 . He also recommends the determination of P_2O_5 in the precipitate after ignition and weighing. His method is: Dissolve 2.5 gms. in 10 c. c. HCl, evaporate to dryness, take up with HCl, boil, rinse into a 250 c. c. flask with as little water as possible, add 10 c. c. concentrated H_2SO_4 and let stand 5 minutes with frequent shaking. Fill up to the mark with alcohol (95 per cent.) so that when cold and well mixed the bulk is 250 c. c. Let stand one hour, filter off 200 c. c. and evaporate to small bulk, dilute to 50 c. c. or over, boil a short time with Br. and precipitated with ammonia, wash with NH_4Cl solution. Ignite, weigh, redissolve, determine P_2O_5 , and deduct.

Teschemacher and Smith note that in case Mg is present in the sample, the precipitate of iron and alumina phosphate must be boiled once or twice with NH_4NO_3 to remove it.

Separation of Titanium, Chromium, Aluminum, Iron, Barium and Phosphoric Acid. Chatard. (*Amer. Chem. Jour.*, xiii. 106). In rock analysis the silica and other bases are determined by ordinary methods. To separate and determine the above compounds, 2 gms. of the pulverized rock are treated with H_2SO_4 (1 : 1) and HFl in a platinum dish, and heated for some time until all HFl has been expelled. A few drops of HNO_3 and more HFl is then added, and it is again heated to expulsion of HFl. Then 25 c. c. HCl (1 : 5) is added and heat is applied until the most of the HCl has been driven out. The entire contents of

the dish is then transferred to a beaker, the bulk of the solution brought to about 250 c. c. and after standing some hours it is filtered. The insoluble portion consisting of BaSO_4 together with undecomposed mineral, is fused with Na_2CO_3 , leached with water, and the barium dissolved from the residue by HCl , from which it is precipitated by H_2SO_4 for weighing. The filtrate and the solution from the Na_2CO_3 fusion of any undecomposed mineral are added to the main solution. This solution is rendered alkaline by ammonia, the just acid by HCl , and finally a little acetic acid and a slight excess of ammonia are added, and it is brought to a boil. The object here is simply to get rid of the lime and magnesia and the accumulation of salts.

After dissolving the precipitate in HCl , the solution is evaporated finally in a large platinum crucible, to a pasty condition. After adding a little water, dry Na_2CO_3 is carefully stirred in, and the mass is dried, and finally fused for half an hour. Then a little NaNO_3 is added, and it is fused for not over five minutes; after cooling, leach out with water. In the insoluble portion, after dissolving in HCl , the TiO_2 is determined by Gooch's method. The filtrate is heated and ammonium nitrate cautiously added until no further precipitation of alumina occurs. The precipitate contains the phosphoric acid, but not all of the alumina. The molybdate separation may be used. In the filtrate containing chromic acid and alumina, the Baubigny method of separation is applied (bicarbonate) to remove the last of the alumina.

Traces of Copper. Thoms. (*J. Pharm.*, [5], xxiii., 27) found that distilled water containing 1 : 200,000 of Cu gave no indications with ammonia or with ferrocyanide, but on adding a little KI , a faint yellow color developed, which gave a distinct blue with starch.

Separation of Copper from Cadmium. Warren (*Chem News*, lxiii., 195) suggests the reversed use of the Fehling test. To the nitric acid solution is added Rochelle salt, followed by NaOH , and then a dilute solution of glucose in small quantities at a time, boiling between each addition, until no further precipitation ensues. Cd may be separated from the filtrate by H_2S .

Dissolving Mercury in toxicological examinations. Lecco (*Berichte* xxiv., 928) finds that Hg is only very slowly attacked by HCl with KClO_3 .

Determination of Mercury. Volhard (*Liebig's Annalen*, cclv., parts 1 and 2) states that HgS dissolves in caustic alkalies in presence of alkaline sulphides, from which solution it can be precipitated by boiling with ammonium nitrate. The solution containing the mercuric form is nearly neutralized with Na_2CO_3 , then completely precipitated by ammonium sulphide, preferably freshly prepared and strong. NaOH solution (made from Na) is added to redissolve, and then NH_4NO_3 added, and the solution boiled until nearly all NH_3 is expelled.

Arsenic in Minerals, etc. Clark (*J. S. C. I.*, x. 444). By distilling As_2S_3 with concentrated solution of Fe_2Cl_6 and strong HCl , all the As was obtained in the distillate. The method can be applied directly to

all minerals containing arsenides or arsenic sulphides. In presence of organic material the addition of slips of copper produces the conditions necessary for the volatilization of the AsCl_3 . When zinc is present or metallic iron (as in pig-irons) some AsH_3 is evolved. The most convenient method of management is to first dissolve the metal in dilute H_2SO_4 , passing the gas through Ag_2SO_4 , filter off the precipitated silver, and mix the filtrate with the undissolved residue containing the rest of the As, and distil with Fe_2Cl_6 and HCl .

Vanadium in Minerals. L'Hôte (*Ann. Chim. Phys.*, [6], xx., 409) mixes the finely pulverized mineral with carbon. If arsenic is present, remove by igniting out of contact with the air. Introduce into a tube, heat the tube in an oil bath to 300° and pass a current of dry chlorine and conduct the gases into water. VdCl_3 in contact with the water gives a red deposit of vanadic acid. Dissolve by H_2SO_4 and Zn and titrate with permanganate.

Qualitative Analysis by Electrolysis. Kohn (*J. S. C. I.*, x., 327) describes the method of testing for some of the metals. The methods may be thus summarized :

Metal.	Conditions—Solutions.	Current = c. c. gas.	Time required.
Sb	K ₂ S. Decompose polysulphides } by warming with H_2O_2	1.5 to 2 c. c.	1 hour.
Hg			
Pb	HNO_3 solution, (NH_4) ₂ C_2O_4 solution }	4 to 5 c. c.	$\frac{1}{2}$ hour.
Cu			
Ag	HNO_3 or H_2SO_4 solution	2 to 3 c. c.	1 hour.
Au			
	KCy solution	1 to 1.5 c. c.	1 hour.

From HNO_3 solution the lead is deposited as PbO_2 on the positive electrode, in all other cases (including (NH_4)₂ C_2O_4 solution of lead) the metal is deposited on the negative electrode. The delicacy of all these tests is stated to be 1 in 1,500,000, except copper which is put at 1 in 3,000,000. Urine in the solution diminishes the delicacy, and requires a longer time.

Electrolytic Determination of Copper. Croasdale (*Jour. Anal. and App. Chem.*, x., 184) continues his article on this subject, giving brief descriptions of methods of separation from almost all the other metals, as described by various authorities, supplemented by his own experiments.

Electrolytic Determination of Mercury. Smith (*Jour. Anal. and App. Chem.*, x., 202). Solution of the sulphide in fixed alkaline sulphide was used. Strength of current 2 c. c. gas per minute. Alone, or when in solution together with As or Sn, the Hg was completely separated.

Electrolytic Determination of Gold. Smith (*Jour. Anal. and App. Chem.*, v., 204). Separation from Sn were not achieved by the methods tried, but successful separations from As, Mo, W and Vd were effected.

Electrolytic Separation. Smith (*Am. Chem. Jour.*, xiii., 417) gives an account of experiments in electrolyzing cyanide solutions, describing the conditions for separating Au alone and when mixed with Cu, Co, Ni, Zn and Pt solutions, also for the separation from Pt of Ag, Cd and Hg. The currents used afforded from 0.2 to 1 c. c. of gas per minute.

Electrolytic Separation of Rhodium. Smith (*Journ. Anal. and App. Chem.*, v., 201). A solution containing $\text{Na}_2\text{Rh}_2\text{Cl}_6$ together with 30 c. c. Na_2HPO_4 (Gr. 1.0358) and 3 c. c. phosphoric acid (Gr. 1.347) was found to be the best. The current afforded 1.8 c. c. gas per minute. The metal was completely deposited in seven hours.

Electrolysis in Sulpho-Cyanate Solutions. Frankel (*Jour. Franklin Inst.*, January, 1891), has investigated this subject and finds that Hg and Au can be readily separated quantitatively; Cd and Bi are deposited in a spongy form; Sb is deposited in a non-adherent coat; Pd, Ni, Co and Zn are first deposited and then dissolved by the action of the current. Results were quite unsatisfactory for quantitative estimations of Fe, Mn, Pb, and Sn by this means. The strength of current used was about 1 c. c. of gas per minute.

Sulphur in Coal. Neilson (*Chem. News*, lxiii., 192) reports comparative results by six different methods on the same sample (a hard coke). The method by mixing 1 gm. of the sample with 2 gms. CaCO_3 in a platinum dish, heating to low red until the carbon is burned off, then dissolving with water with addition of Br water and HCl, boiling, filtering and finally precipitating with BaCl_2 , gave higher results than the others (heating with MgO , or fusion with alkaline nitrate and carbonate), but accorded well with a new method which is described. It consists in heating 1 gm. of the coke mixed with 2 gms. Na_2CO_3 and 0.5 gm. MnCO_3 to low red until the carbon is burned off. It is then fused, extracted with HCl, evaporated to dryness, filtered and precipitated as usual. A blank test for correction of the results is necessary.

Determining Sulphur. Treadwell (*Berichte*, xxiv., 1937) recommends to heat to low red the substance mixed with pure iron (terrum reductum, iron by hydrogen) for about 10 minutes in a current of CO_2 , which affords FeS . By treatment of this product with HCl in an atmosphere of hydrogen, all S is evolved as H_2S , which may be passed into ammoniacal H_2O_2 , and determined as BaSO_4 or estimated iodometrically, etc. The S in BaSO_4 may be determined by this means, though longer heating is required. The method is intended only for application to mineral sulphides.

Rusted Pig-Iron Drillings. Donald (*News*, lxiii., 73) found that by rusting, some combined carbon, but more of the graphite was lost.

Carbon Monoxide. Berthelot (*Comptes Rendus.*, cxii., No. 12) finds that ammoniacal silver nitrate is quickly reduced by this gas.

Kjeldahl's Method for Nitrogen. Kebler (*Jour. Anal. and App. Chem.*, v., 257) gives an index to the literature on the estimation of nitrogen, more especially the Kjeldahl method.

Nitrogen in Water. Wagner (*Jour. Phar. Chim.*, xxiii., 5) applies the Kjeldahl method thus: Nitrates and nitrites are first reduced to ammonia by the zinc copper couple and H_2SO_4 in 500 c.c. of the water, until there is no reaction for HNO_2 . The water is then evaporated to about 5 c.c. Then 0.5 gm. CuO and 10 c.c. of 6 parts ordinary concentrated H_2SO_4 with 4 parts fuming sulphuric acid are added, and the operation carried through as usual, except that Rochelle salt is added, together with the alkali, when the NH_3 is to be distilled off for titration.

Analysis of Nitrates. Ulsch (*Fres. Zts. Anal. Chem.*, xxx., 175) regards methods involving the use of metallic zinc, and determination of the ammonia formed, as faulty, since with zinc there is some loss of nitrogen. He prefers to use metallic iron with dilute H_2SO_4 , which gives no nitrous acid. Iron which has been reduced by hydrogen he found most satisfactory, though some kinds of iron filings worked well. He notes that a reduction to ammonia is effected, even if the nitrate solution is added after all the metal has dissolved. He describes also a method for the determination of nitrate, by measurement of the deficit in hydrogen evolved by a known amount of iron.

Estimation of Nitrates. McGowan (*Proc. Lond. Chem. Soc.*, No. 97, p. 84). In an apparatus from which the air has been expelled by CO_2 , the nitrate is warmed with an excess of concentrated HCl . The reaction is $\text{HNO}_3 + 3\text{HCl} = \text{NOCl} + \text{Cl}_2 + 2\text{H}_2\text{O}$. The gases are passed through KI solution and the liberated iodine titrated. All three Cl atoms react upon the KI while NO escapes.

Nitrates in Potable Waters. Harrow (*J. Lond. Chem. Soc.*, lix., 320) offers the following method: A beaker containing 50 c.c. of the water is placed on a sheet of white paper, side by side with others containing known amounts of nitrate. To each is added 10 c.c. of a solution (made by dissolving 1 gm. (alpha) naphthylamin, 1 gm. sulphuric acid, and 25 c.c. HCl in about 200 c.c. boiling with a little bone-black, filtering and diluting to 500 c.c.) 0.007 to 0.008 gm. zinc dust is added to each beaker. At the end of 15 minutes the colors can be compared. The reaction, of course, consists in the formation of nitrous acid, and the reaction of that substance, as in Griess' test.

Nitrates in Water. Bartram (*Jour. Franklin Inst.*, March, 1891) finds that in the phenol sulphonic acid method (Grandval-Lajoux), when the reagent is freshly prepared, the results are unaffected by the presence of chlorides in the water, but if the reagent has stood for some time, the influence of the chlorides, especially when proportionately large to the amount of nitrate, causes results to be 20 per cent. or more too low.

Nitrates in Water. Hazen and Clarke (*Jour. Anal. and App. Chem.*, v., 301) find that the phenol sulphonic process gives low results, especially when much chlorine is present. The colors could not be matched by solutions of picric acid. The compound formed seems to match more closely (though not exactly) the tints obtained with ortho-mono-nitro-phenol.

The aluminum process was more satisfactory. The hydrogen evolved

may in practice carry off 2 per cent. of the ammonia. For most waters it was found that the solution could be nesslerized directly, without distillation. The amount of nitrate reduced is proportional to the Al dissolved, whatever the bulk of the solution. The higher the temperature the less Al required. When the NaOH contained Zn it was less efficient. With natural waters the action was slower than with distilled waters. Al foil, 0.005 inch thick, was found to be the best form.

Analysis of Dynamite, etc. Scheiding (*Zts. angew. Chem.*, 1890, 614). Extract with ether. This removes nitro-glycerol,—evaporate off the ether at ordinary temperatures, dry over H_2SO_4 and weigh. Heating must be avoided as the nitro glycerol will volatilize perceptibly even at 40°C .

A determination of the moisture in the residue, is usually all that is required with dynamite. In blasting gelatine, however, it may be necessary, after removing nitro-glycerol, to extract nitrate (and possibly other salts) with water; then re-dry and extract lower nitro-celluloses by ether and alcohol (2 : 1) and finally trinitro-cellulose by ethyl acetate. The residue may be examined for sawdust, chalk, magnesia, barytes, etc. The last is reckoned as an adulterant.

If other nitro compounds than nitro-glycerol are extracted by ether, determine the nitro-nitrogen by Schultze's FeCl_3 process.

Determination of Oxygen. De Koninck (*Zts. angew. Chem.*, 1891, 78) has investigated Wanklyn and Cooper's suggestion as to the method with NO. Theoretically the reactions should be $2\text{NO} + \text{O}_2 = 2\text{NO}_2$ and $2\text{NO}_2 + \text{H}_2\text{O} = \text{HNO}_3 + \text{HNO}_2$. By experiment, however, it appeared that this reaction only, did not occur. The amount of contraction was not constant, nor in accordance with this theory.

Estimation of Oxygen. De Koninck (*Zts. angew. Chem.*, 1890, 727) uses as an absorbing solution a mixture of FeSO_4 , Rochelle salt, and KOH solutions. He makes up: A. 40 gms. FeSO_4 in 100 c.c. water, B. 30 gms. $\text{KNaC}_4\text{H}_4\text{O}_6$ in 100 c.c. and C. 60 gms. KOH in 100 c.c., then adds one volume of A to five volumes of B. A white precipitate forms, which is dissolved by adding one volume of C. Unless mixed in this manner, a clear solution is not obtained. The solution should be clear for use.

Analysis of Illuminating Gases. Lewes (*J. S. C. I.*, x., 407) reports interesting investigations on the subject. He finds Stead's apparatus to be the most satisfactory, and uses two, one with mercury, the other with water. Both must be accurately calibrated. His procedure is: 1st. CO_2 and H_2S are absorbed by a 50 per cent. NaOH solution, agitating for 10 minutes. With gases containing over one per cent. CO_2 and of H_2S the absorption must be done over mercury.

2. O—absorbed by alkaline pyrogallate. Allow full 20 minutes with agitation. The solution must not be too freshly made, nor should it have been used more than three or four times, since CO is given off after a certain proportion of O has been absorbed.

3. Unsaturated hydrocarbons,—absorbed by Br in KBr solution with

gentle agitation for 15 minutes. Absorbs the Br vapor by NaOH before measuring.

4. CO—absorbed by acid Cu_2Cl_2 . Agitation for 20 to 30 minutes. This estimation is the least satisfactory of any, it being exceedingly difficult to absorb the last portions of the gas.

5. Saturated hydrocarbons—partially absorbed by paraffin oil, by agitation for 30 minutes. Ethane, butane, etc., are entirely absorbed. Experiments showed, however, that only about two-thirds of the methane was absorbed.

A portion of the remaining gas is run into the mercury endiometer, measured, mixed with excess of oxygen, and exploded. The CO_2 formed absorbed by NaOH then gives the volume of methane unabsorbed by the paraffin oil. The taps of the apparatus should be held in place by rubber bands, as the shock tends to loosen them, and cause leakage. The pressure must not be too much reduced before exploding, or the combustion will be incomplete.

6. Absorb the remaining oxygen by alkaline pyrogallate, take the residual gas as nitrogen, estimating hydrogen by difference.

For acetylene and H_2S Winkler's method is used—passing the gas through two absorbing bottles containing concentrated ammoniacal silver nitrate. The precipitate is filtered and washed and then treated cautiously with dilute HCl. The AgCl in the precipitate is dissolved out by ammonia and precipitated by HNO_3 1 gm. AgCl = 0.09068 gm. acetylene or 78.0314 c.c. The residue insoluble in ammonia, should be oxidized, and the sulphur determined gravimetrically, especially if the gas contains much CO, which also precipitates silver solution. For sulphur compounds other than H_2S , the gas after leaving the silver solution must be passed over platinized asbestos or pumice heated to 400°C . which converts them to H_2S in the presence of hydrogen. This is passed into lead solution and estimated in the usual way.

Prof. Lewes also gives a paper on the analysis of the products of incomplete combustion. (*ib.* p. 413.)

MINERALOGY, BY A. J. MOSES.

AN ESPECIAL ARRANGEMENT OF THE WOLLASTON GONIOMETER.*

"In laboratories, the measurement of diedral angles of crystals is ordinarily made with the Wollaston's goniometer, using with it, as a luminous signal, a horizontal slit in a screen which covers a gas flame. As a point of reference, use is made of any line whatever in the plane which is perpendicular both to the horizontal slit and to the axis of rotation of the goniometer, or, which is a great deal better, of the image of the slit itself in a small mirror fixed at the base of the goniometer; the mirror being so arranged that its plane is parallel to the axis of rotation of the goniometer."

"The measurements are effected by two classes of errors; those due to the almost inevitable variation of the position of the eye during the measurements; the other, generally more considerable, results from the impossibility of placing the crystal in such a manner that the axis of

* The work of translation was in part performed by Mr. L. M. Luquer.

rotation shall be exactly included in the plane which bisects the diedral angle to be measured.*

"These two errors are annulled when the distance from the luminous signal to the crystal is infinite. Practically, this distance can but little exceed a few metres, which makes possible errors of four to five minutes."

"For very precise measurements a goniometer with a vertical axis is used, upon which are installed a collimator, the luminous slit of which serves as a signal, as well as a telescope provided with cross hairs by the aid of which the images reflected from the crystal faces are observed. This arrangement eliminates the two fundamental errors which we have described, but it makes the measurements much too difficult and too tedious. Not only does the interposition of the telescope between the crystal and the eye cause the loss of a great deal of light, but more especially it makes that most delicate and tedious portion of the measurement, the orientation of the crystal on the axis of rotation, much more laborious."

"To combine as completely as possible the precision of the goniometer with a telescope with the ease of manipulation of the ordinary Wollaston goniometer." Mallard uses the following arrangement:

"This consists essentially in substituting for a luminous signal, placed as far as possible from the goniometer, a luminous slit placed at the focus of a large lens, and thus forming a true collimator that can be placed very near the goniometer. The ordinary mirror of the goniometer is adjusted with reference to the crystal in such a manner as to receive the luminous rays emerging from the collimator at the same time as the crystal does. The image of the luminous slit reflected by the mirror, is taken for a line of reference."

"Since the luminous signal and the line of reference can both be considered as at infinity, the errors of parallax are eliminated. The measurements are made with as great ease as in case of an ordinary (Wollaston) arrangement. Besides, the light reflected by the crystal faces is more intense, and all the apparatus, comprising the goniometer, the luminous signal and the line of reference are included in a small space. The details of the arrangement are represented in Fig. 1."

"L is the lens of the collimator, which ought to be so large that while the central portion of the ray falls upon the crystal, A, the mirror, M, may also receive a portion of this ray."

I use a lens of 0.10 m. in diameter. It does not need to be perfectly achromatic. It is sufficient that the central part of the ray, which falls on the crystal should be so. The image reflected by the mirror, M, is made achromatic by colored glasses placed before the mirror."

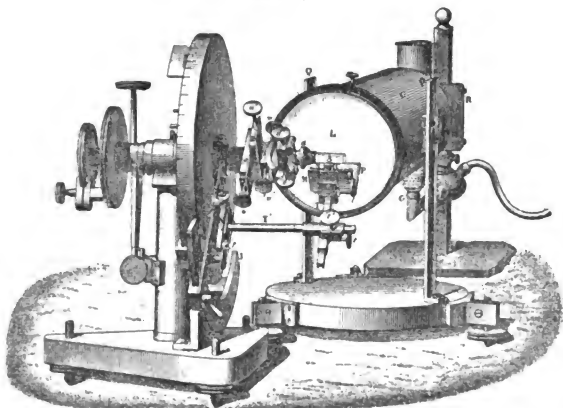
"C is the cylinder of the collimator, blackened on the inside; it is supported by two grooved uprights, Q Q, between which it can slide and to which it can be fixed by clamp screws. When necessary it is possible to so arrange that the cylinder can be inclined from the horizontal by turning around on axis, carried by the screw *q*; but this is not indispensable."

"The cylinder is closed by the lens, L, carried by a tube which fits closely in the cylinder, C, and is fixed by means of the clamp screw, *c*, when the rear end is exactly in the focal plane of this lens."

† See for details Mallard's *Traite de Crystallographie*, i., 221-226.

"The rear end is closed, with the exception of quite a large central orifice. In front of this orifice, in a conveniently arranged groove, slides a metallic plate, R R, represented in detail Fig. 2. It carries slits of various forms, f, f', f'' , which can be successfully be placed at the

FIG. 1.



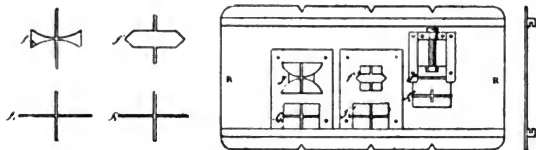
centre of the orifice. When one of these slits is placed in this position a little ratchet and pawl holds it there."

"The slit is illuminated by a gas jet, C."

"For an ordinary crystal I use the slit f , Fig. 4, employed by Websky. When the crystal faces are dull and a great deal more light is needed, I use the window f'' ."

"It is possible in the measurements to superpose the image of the

FIG. 2.



luminous slit, seen by reflection from the crystal, with that of the same slit seen by reflection from the mirror. When this superposition is obtained the mirror and the crystalline face are parallel, and the superposition will not cease to exist if the relative positions of the goniometer and the collimator are changed in any way whatever, or even if the luminous slit is displaced in the focal plane."

"But a close precision is not reached, especially when the image given by the crystal face is not very good, by superposing two images of the same slit. It is better to place a little below the first slit, which I shall call the *signal slit*, and which has one of the forms f, f' , another very narrow slit, f_1 (Fig. 2), parallel to the direction of the first, and which I will call the *cross-hair slit*. It is, like the signal, crossed perpendicularly by a small and very fine slit, which ought to be the exact prolongation of the one which crosses the signal slit."

"The very fine cross-hair slit does not give, usually, a clear image by reflection on the crystal faces, but it gives by reflection in the mirror a very clear image, colored by the glass P. It is upon this image that the axis of the image of the signal slit, reflected by the crystal, is superposed, thus making use of the image of the cross-hair slit seen in the mirror as a true cross hair. There is reached in this way an exactness which, with good crystal faces, attains easily the minute and even the half-minute."

"It is true that with this method of working the crystal face and the mirror are no longer strictly parallel when the crystal image of the signal slit is superposed upon the mirror image of the cross-hair slit. The position of the goniometer with reference to the collimator is no longer indifferent, and it is necessary that the axis of the goniometer should be perpendicular to that of the collimator. But the angle that the crystal face makes with the mirror at the moment of superposition is equal to the angle subtended by the distance between the two slits, with the optical centre of the lens as a centre. This angle, which is only 2° to 3° , is small enough to allow adjusting the relative positions of the goniometer and collimator in a very approximate manner."

"The mirror can be inclined 40° – 50° to the horizon, and for accuracy provision is made for the slight movement necessary in adjusting. This adjusting, which has for its object the placing of the mirror strictly parallel to the axis of rotation, is made very simply by placing at the extremity of the axis of the goniometer a plate with parallel faces, such as a very regular little (cleavage) fragment of felspar. The mirror is adjusted when the two images given by each of the two faces of the plates can be brought, by rotation of the axis of the goniometer, into superposition with the image reflected by the mirror."

"The crystals to be measured may have very different dimensions; it is, therefore, convenient to be able to move the mirror while always maintaining it parallel to itself. There is, therefore, given to the support of the mirror three movements of translation perpendicular to each other, and of which one is in the direction of the axis of the goniometer."

"The arrangement just described can be adapted to any goniometer, but the measuring becomes more easy when the crystal is supported in the manner suggested by Groth. The crystal, fixed with wax on a small circular disc, d (Fig. 1), can receive—and this is indispensable—two movements of rotation on two arcs of circles perpendicular to each other and having their common centre situated towards the middle of the crystal, A, so that the changes of orientation of the crystal do not too much displace its centre of gravity. The two sliding motions are obtained by turning the screws v, v , and v', v' ."

For the proper centring of the crystal it is convenient to fix the entire system which holds the crystal to two sliding planes, g and g' , which, by means of the screws u and u' permit giving to the crystal two movements of translation in a plane perpendicular to the axis of rotation."

Translated and somewhat condensed from a paper by M. Er. Mallard in *Annales des Mines*, S. 8. t. xii., Nov.-Dec., 1887.

AGUILARITE, *Genth*, $Ag_xS.Ag_ySe$. *Isometric*.

One of half a dozen pieces of supposed naumanite from the San Carlos mine, Guanajuato, Mexico, was pure mineral; the others were more or less altered to a cupriferous stephanite. The description of the unaltered specimen is as follows:

Occurs in groups of skeleton dodecahedral crystals, not over 10 mm. by 6 mm. in size, with only the edges perfectly developed. The crystals are frequently elongated so as to resemble tetragonal and hexagonal forms. No cleavage observed; $H = 2.5$; $G. = 7.586$; lustre, very brilliant; color, iron black; fracture, hackly. In open tube, at low and then red heat, yielded metallic silver, sublimate of selenium and silky needles of selenous oxide. Analysis showed:

Ag,	.	.	.	.	.	.	.	.	.	.	79.07
S,	.	.	.	.	.	.	.	.	.	.	5.86
Se,	.	.	.	.	.	.	.	.	.	.	14.82
											<hr/>
											99.75

Named after the superintendent of the mine, Señor Aguilar.—*Amer. Journ. Sci.*, xli., 401-402, May, 1891.

ALBITE.

Russian albites crystallographically described.—S. Glinka, *Neues Jahrbuch*, 1891, i., 218-228.

ALUNITE.

W. Cross describes the occurrence of alunite rock at Democrat Hill and of an alunite diaspore rock at Mt. Robinson, in the Rosita Hills, Colorado. The alunite rock of Democrat Hill is cellular, the cells being lined by rudely tabular crystals obscured by minute quartz crystals. Microscopical and chemical examinations prove the tabular crystals to be alunite, and the rock to be two-thirds quartz, one-third alunite.—*Amer. Journ. Sci.*, xli., 466-469, June, 1891.

ALUNOGEN. *Keramohalite* of Teneriffe.

The "haarsalz" found in the crater at the summit of Pico de Teyde, in the Canary Islands, is a yellowish gray-white, hygroscopic, coarse granular mass which consists chiefly of crystallized material. Crystals, mechanically separated, are small, feebly lustrous, and imperfectly formed; monoclinic augite-like in form. $\beta = 97^\circ 34'$ $a:b:c :: 1:?:0.825$.

They are easily separated by solution in water from the insoluble components, sulphur and various silicates; and a very satisfactory analysis is possible.

SO ₃	.	38.62		Al ₂ (SO ₄) ₃	.	46.81
Al ₂ O ₃	.	13.96		Fe ₂ (SO ₄) ₃	.	2.35
Fe ₂ O ₃	.	0.94		FeSO ₄	.	1.39
FeO	.	0.66	Corresponding to	CaSO ₄	.	0.53
CaO	.	0.22		MgSO ₄	.	0.12
MgO	.	0.04		Na ₂ SO ₄	.	6.43
Na ₂ O	.	2.37				
H ₂ O	.	42.01		H ₂ O	.	42.01
		<hr/>				<hr/>
		98.82				99.64

—Hof and Becke, *Tschermak's Min. Mittheil.*, xii., 39–48, 1891.

ARAGONITE.

Description of crystallization at Leogang, Salzburg, and bibliography.—*Zeit. f. Kryst.*, xix., 140–146, 1891.

ASTROPHYLLITE.

L. G. Eakins analyzes the astrophyllite of St. Peter's Dome, Pike's Peak, Col.; the results agreeing very well with Brögger's formula R''R'Ti(SiO₄).—*Amer. Journ. Sci.*, xlii., 34–36, July, 1891.

AWARUITE.

G. H. F. Ulrich on the discovery, mode of occurrence and distribution of the nickel-iron alloy, awaruite, on the West Coast of the South Island of New Zealand.—*Quart. Journ. Geolog. Soc.*, Nov., 1890.

AXINITE.

Description of specimens from Franklin, N. J.; Guadalcázar, Mexico, and McKay's Brook, Northumberland Co., N. S., by F. A. Genth, S. L. Penfield and L. V. Pirsson.—*Amer. Journ. Sci.*, xli., 394–397, May, 1891.

AZURITE.

Measurements of crystallized azurite from Arizona. O. C. Far-
rington.—*Amer. Journ. Sci.*, xli., 300–307, April, 1891.

BARITE.

Study of mode of occurrence and crystalline form of the barite of the Hüttenberger, Erzberges.—*Tschermak's Min. Mittheil.*, xii., 62–81, 1891.

BERNARDINITE.

Originally described as a fossil resin, later as a recent resin, is now shown by J. S. Brown to be a fungous growth enclosed in resinous material.—*Amer. Journ. Sci.*, xlii., 46–50, July, 1891.

BERTRANDITE.

M. L. Michel reports the discovery of this species at Limoges, Haute Vienne.—*Bull. Soc. Franc. Min.*, xiv., 76, March, 1891.

CALCITE.

"Contributions to knowledge of crystalline form of calcite," describes calcites of Reidlingen, Tülingen, Badenweiler, Kandern, Döggern, Waldshut, St. Blasien, Uffhausen, Kaiserstuhl, Münsterthal, Hausach, S. Wenzel, Wolfach, and Schapbachthal.—F. Sansoni, *Giornale de Mineralogia*, i., 299-316, 1890.

CELESTITE.

Description of crystallization at Leogang, Salzburg and bibliography.—*Zeit. f. Kryst.*, xix., 153-161, 1891.

COLUMBITE of the Black Hills, S. Dakota.

W. P. Blake, *Amer. Journ. Sci.*, xli., 403-405, May, 1891, crystallographic study by S. L. Penfield.

CORYNITE.

Laspeyres considers it to be a normal ullmannite with considerable but varying admixture of gersdorffite.—*Zeit. f. Kryst.*, xix., 11, 1891.

DATOLITE.

Study of a crystal from Andreasberg.—K. Busz, *Zeit. f. Kryst.*, xix., 21-24, 1891.

DIASPORE of the Rosita Hills.

With the alunite rock of Mt. Robinson there is much of a rough finely cellular rock composed of bluish quartz and irregular grains of some transparent colorless mineral with noticeably brilliant cleavage. Chemically and optically it agrees with diaspore and the subsequent finding of clear prismatic crystals proved its identity (the crystals are described by W. Melville, pp. 475-477). W. Cross, *Amer. Journ. Sci.*, xli., 469, June, 1891.

DOLOMITE.

Crystallographic study by F. Becke, *Tschermak's Mittheil.*, 1888, x., 93 and 1890, xi., 221-224. Abstract in *Zeit. f. Kryst.*, 1891, xix., 189-196.

Description and bibliography of dolomite of Leogang, Salzburg.—*Zeit. f. Kryst.*, xix., 139-140, 1891.

EKDEMITE AND HELIOPHYLLITE.

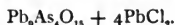
The distinction between these two closely related species was said to be that ekdemitite was tetragonal, and heliophyllite orthorhombic. Hamberg finds that the heliophyllite of Harstig, consists of two types, in one of which, the larger tabular crystals, sections parallel to the base show alternating lamellæ of uniaxial and biaxial material crossing at right angles, the other type, which consists of acute tetragonal pyramids, show, in similar section, a uniaxial groundmass with streaks of biaxial material in various directions.

Also a thin plate of Nordenskiöld's ekdemite of Langban proved not to be homogeneous, but showed the biaxial streaks corresponding to type 2. Hamburg therefore holds that no optical ground exists for the separation of the species.

As to the slight chemical difference the author compares the already known analyses with two of his own.

	Nordenskiöld ekdemite of Langban.	Flink so-called heliophyllite of Harstig.	Hamburg Type No. 1. Type No. 2.	
PbO,	83.45	80.70	81.03	80.99
FeO + MnO, . . . . .	.....	0.54	0.07	0.16
CaO, . . . . .	.....	.....	0.08	0.11
As ₂ O ₃ ,	10.60	11.69	10.85	10.49
Sb ₂ O ₃, . . . . .	.....	.....	0.56	1.38
Cl,	8.00	8.00	8.05	7.96
	<hr/>	<hr/>	<hr/>	<hr/>
	102.05	100.93	100.64	101.09
O,	1.80	1.80	1.80	1.79
	<hr/>	<hr/>	<hr/>	<hr/>
	100.25	99.13	98.84	99.30

Flink's and Hamberg's analyses compare well and lead to a formula intermediate between those given for ekdemite and heliophyllite, viz.:



These analyses appear to indicate that the two types of heliophyllite and the ekdemite are practically of the same composition and as their optical differences are not irreconcilable (possibly due to pressure), a separation is not necessary. The name ekdemite has preference.—*Zeit. f. Kryst.*, xix., 105-107, 1891.

ENARGITE.

Crystals 2.5 c. m. long and 1.5 c. m. wide from Cerro Blanco mines, Atacama, Chili.—*Zeit. f. Kryst.*, xix., 76, 1891.

EPISPHAERITE, *Knop*.

White radiated fibrous globes on natrolite in the phonolite of Oberschaffhausen.—*Zeit. f. Kryst.*, xviii., 668, 1891.

EUDIALYTE from Magnet Cove, Ark.

Analysis and crystalline form, Genth and Penfield, *Amer. Journ. Sci.*, xli., 397, May, 1891.

FALKENHAYNITE, *Scharizer*. $\text{Cu}_6\text{Sb}_2\text{S}_6$.

A new steel-gray mineral with black streak, of the wittichenite group. Found on a single specimen from Fiedlergange, Joachimsthal, associated with chalcopyrite and siderite:

S.	Sb.	As.	Bi.	Cu.	Fe.	Zn.	
26.21	23.10	4.77	0.32	39.51	4.20	1.89	100.00

quartz, magnesia and carbonate of iron were deducted.—*Jahrb. Geol. Reichs.*, xl., 433, 1890.

Sandberger points out its relation to annivite, states that it is identical with the mineral which Vogl called tennanite from Geistergange, Joachimsthal and that both Scharizer's and Vogl's mineral could well be classed under the name annivite, a variety of tetrahedrite.

Falkenhaynite G = 4830.				Annivite.			
S,	25.760			S,	26.42		
Sb,	24.299	9.560	Sb_2S_3	Sb,	9.79	3.85	Sb_2S_3
As,	5.018	3.211	As_2S_3	As,	12.20	8.48	As_2S_3
Bi,	0.337	0.077	Bi_2S_3	Bi,	5.50	1.26	Bi_2S_3
Cu,	39.770	10.036	Cu_2S	Cu,	39.57	9.98	Cu_2S
Fe,	2.826	1.614	Fe_2S	Fe,	4.28	2.44	FeS
Zn,	1.990	0.979	ZnS	Zn,	2.24	1.10	ZnS
		25.477				27.11	

—*Neues. Jahrb. f. Min.*, 1891, i., 274-275.

FAYALITE.

Lacroix describes small crystals of fayalite with biotite, magnetite, and hypersthene implanted on orthoclase and tridymite in the volcanic enclosures of the trachytes of Capucin Mont Dore.—*Bull. Soc. Franc. Min.*, xiv., 10-14, January, 1891.

A ten pound mass of fayalite from Cheyenne Mt., Colorado, yielded :

SiO_2,	.	.	.	.	.	.	.	.	.	27.66
FeO},	.	.	.	.	.	.	.	.	.	65.94
MnO},	.	.	.	.	.	.	.	.	.	4.17
CaO},	.	.	.	.	.	.	.	.	.	0.47
										98.24

—*Amer. Journ. Sci.*, xli., 439, May, 1891.

FERGUSONITE.

Hidden records these four localities: Near Amelia Court House, Va., small crystals on orthite; near Storeville, Anderson Co., S. C., with zircon, columbite, garnet, etc.; near Spruce Hill, Mitchell Co., N. C., altering crystals with allanite and cyrtolite; near Golden P. O.; Rutherford Co., N. C., in the gold placers.—*Amer. Journ. Sci.*, xli., 440, May, 1891.

FERRONATRITE.

Mackintosh's* sulphate of iron, called by him ferronatrite, proves to be identical with the gordaite of Frenzel, the name ferronatrite having priority. Frenzel states that he was misled by the description and percentage of water. Ferronatrite from Chili is pale, whitish green, radiated like wavellite, associated with copiapite and coquimbite, and yields $5\frac{1}{2}$ molecules water at 110°C .

Gordaite from Sierra Gorda, near Caracoles, Chili, is in white, broad tabular, usually cleavable masses, intergrown with sideronatrite, yielding no water at 100°C .

The determination of Genth and Penfield,† of ferronatrite from Sierra

* *Amer. Journ. Sci.*, 1889, xxviii., 244.

† *Ibid.*, 1890, xl., 202.

Gorda in white cleavable masses, probably hexagonal, led Frenzel and Arzruni to a re-examination of Gordaite, with the result that Frenzel admits its identity with ferromagnetite, with the formula $3\text{Na}_2\text{SO}_4 \cdot \text{Fe}_2(\text{SO}_4)_3 + 6\text{H}_2\text{O}$; and Arzruni describes the crystals as short, columnar or needle-like, undoubtedly of rhombohedral form $a : c = 1 : 0.55278$; with cleavages parallel to the prisms of the first and second order, thus giving frequently the rectangular forms which misled Frenzel—*Zeit. f. Kryst.*, xviii., 593-598, 1891.

FLUOCERITE.

The analyses of the common compact variety led to the formula $(\text{Ce}, \text{La}, \text{Di})_2\text{O} (\text{F}, \text{OH})_4$, or suggested a basic fluoride of the same bases, which had been subjected to the commencement of a decomposition by the interchange of fluorine and water. The crystalline form had only been approximately determined by optical methods.

M. Weibull obtained last year two rough crystals in the quartz of Osterby, Delarne, Sweden, which he separated from the quartz by hydrofluoric acid. The faces were plane, but too rough for measurement, except by the contact goniometer. The crystals were hexagonal prismatic; one showed both prisms and a face of the second order pyramid; the other crystal showed one prism and a trace of the other, and an unmistakable basal cleavage. The approximate ratio $a : c = 1 : 1.06$ is given.—*Zeit. f. Kryst.*, xviii., 619, 1891.

GARNET.

Yellowish-brown lustrous crystals from Rothenkopf, Zillerthal, showed the new face 853.—*Zeit. f. Kryst.*, xix., 188, 1891.

Pink *Grossularite* from Xalostoc, District of Cuautla, Morelos, Mexico. C. F. De Landero, *Amer. Journ. Sci.*, xli., 321-323, April, 1891:

SiO_2	40.64
Al_2O_3	21.48
Fe_2O_3	1.57
CaO	35.38
MgO	0.75
$\text{MnO} \cdot \text{BaO}$	trace.
Insol.	0.17
	<hr/> 99.99

G., 3.516; H., 7.5; fusibility, below 3; formula $(\text{Ca}, \text{Mg})_3(\text{Al}, \text{Fe})_2\text{Si}_3\text{O}_{12}$; form, ∞O .

Almandite of Fort Wrangel, Alaska. A. F. Kountze, *Ibid.*, 332-333.

	Mean of Analyses.
SiO_2	39.29
Al_2O_3	21.70
Fe_2O_3	trace.
FeO	30.82
MgO	5.26
CaO	1.99
MnO	1.51
	<hr/> 100.57

Melanite. R. Soltman analyzes a melanite from Oberrothweil in Kaiserstuhl, which contains 11.01 TiO_2 and 1.28 ZrO_2 , and in which the sum of the dioxides exceeds the limits of the garnet formula, making the part played by the titanium uncertain.—*Zeit. f. Kryst.*, xviii., 628, 1891.

GLASURITE, *Knop*.

A brownish yellow, glassy coating, from the cavities of the Limburgite of Sasbach, apparently consisting of uniaxial columns.—*Zeit. f. Kryst.*, xviii., 668, 1891.

GMELINITE.

L. V. Pirsson presents a crystallographic and chemical study of the gmelinite of Nova Scotia and suggests that Streng's theory as to the identity of this mineral with chabazite may be accepted if we assume that the large replacement of lime by soda in the gmelinite lengthens somewhat the vertical axis; and notes that in the Five Island material where the difference in axial ratios is greatest the soda is in highest per cent.—*Amer. Jour. Sci.*, xlii., 57-63, July, 1891.

GRIPHITE, *W. P. Headen*. $\text{R}_6\text{P}_2\text{O}_{10}$? *Amorphous*.

Occurs in kidney-shaped masses sometimes weighing over fifty pounds. $\text{H.} = 5.5$; $\text{G.} = 3.401$; lustre resinous-vitreous, color, dark brown, in thin flakes translucent and yellowish-brown; fracture, uneven to conchoidal; brittle. Fuses easily in the flame of a candle and reacts for Mn. Fe. Na, before the blowpipe. Readily soluble in acids. Mean of several analyses is:

P_2O_5 ,	38.52	Na_2O ,	5.52
MnO ,	29.64	K_2O ,	0.30
CaO ,	7.47	Li_2O ,	trace.
Al_2O_3 ,	10.13	H_2O ,	4.29
FeO ,	4.00	Cl ,	0.11
MgO ,	0.15	F ,	trace.
		Insol.,	0.16
			<hr/>
			100.29

—*Amer. Jour. Sci.* xli. 415-16, May, 1891.

HALOTRICHITE.

From Elk Mt., Pitkin County, Colorado. E. H. S. Bailey.—*Amer. Journ. Sci.*, xli., 296, April, 1891.

KALLILITE. WISMUTH-ANTIMONNICKELGLANZ. *Laspeyres*.

These names are given by Laspeyres to isomorphous mixtures of ullmannite (antimonnickelglanz) and the corresponding bismuth compound (wismuth nickelglanz), the name kallilite being especially given to an ore from the Friederich mine near Schönstein, Siegen; where it occurs in pure masses containing nearly 12 per cent. Bi, with cubical cleavage and accompanied by siderite, quartz and occasional needles of millerite.—*Zeit. f. Kryst.*, xix., 12-17, 1891.

KORARFVEITE.

Radominsky's kårarfveit (kårarfveit), made a species on ground of high fluor contents (4.35 per cent.) is according to analysis of Blomstrand, upon specimen from same locality collected in the same year, only a common impure monazite $F = 0.33$.—*Zeit. f. Kryst.*, xix., 109, 1891.

L^oAVENITE.

Lacroix records microscopic crystals of lävenite, in the nephilitic phonolite of Haute Loire.—*Bull. Soc. Franc. Min.* xiv., 15-16, Jan., 1891.

MONTICELLITE, from Magnet Cove, Ark.

In microscopic colorless hexagonal prisms and in radiating crystalline masses in a coarse-grained calcite. Analyses and crystalline form given. Genth and Pirsson.—*Amer. Journ., Sci.* xli., 398-400. May, 1891.

NATROLITE.

Crystallographic description of natrolites of Salcedo, Mt. Baldo, Montecchio Maggiore and Altavilla.—G. B. Negri *Giornale di Mineralogia* i., 325-326, 1890.

Savite of Montecatini proved chemically as well as crystallographically identical with natrolite.—*Zeit. f. Kryst.*, xix., 203, 1891.

NEPHELITE.

Discussion of crystallization by H. Baumhauer, *Zeit. f. Kryst.*, xviii., 611-618, 1891.

NESQUEHONITE.

Friedel reports the discovery of a fibrous white mineral in the Anthracite mine of Mure, Isère, which corresponds in composition to the Nesquehonite of Genth and Penfield, found in the Nesquehoning Anthracite mine near Lansford, Pa. The author doubts Genth's formula for the Lansfordite of which Nesquehonite is supposed to be a pseudomorph.—*Bull. Soc. Franc. Min.*, xiv., 60-63, Feb., 1891.

NEWTONITE. *Brackett and Williams.* $Al_2O_3, SiO_2, 4H_2O + aq.$ *Rhombohedral.*

Occurs in soft compact lumps from a few ounces to forty pounds in weight, imbedded in dark green clay at Sneed's creek, Newton county, Ark. Color, pure white; $G. = 2.37$. Under high power is seen to be composed of minute rhombs which are doubly refracting. Infusible; only slightly dissolved in boiling concentrated HCl, but completely by H_2SO_4 or KOH. Analysis shows, after deducting slight impurities and recalculating:

SiO ₂	39.76	40.88
Al ₂ O ₃	36.01	35.85
Loss by ignition,	24.23	23.27
	<hr/> 100.00	<hr/> 100.00

—*Amer. Journ. Sci.*, xlii., 11-16, July, 1891.

NICKEL.

In the auriferous sands of Elvo near Biella, Piedmont; Sella notes malleable magnetic grains which contain Ni and Co 75.2, Fe 26.6 or nearly Ni₃Fe.—*Compte Rendu.*, cxii. 171, 1891.

NONTRONITE.

A nontronite like mineral from the cavities of the Limburgite of Sasbach apparently identical with Saussure's sideroclepte (chrysolite;) forms spherical masses of concentric scaly structure, often changing into yellow and green scales by which the radial structure of the original mineral is erased. Analysis showed:

SiO ₂	.	.	.	.	.	.	.	.	.	.	.	51.20
Al ₂ O ₃	.	.	.	.	.	.	.	.	.	.	.	8.29
Fe ₂ O ₃	.	.	.	.	.	.	.	.	.	.	.	19.62
MgO	.	.	.	.	.	.	.	.	.	.	.	4.04
MnO	.	.	.	.	.	.	.	.	.	.	.	0.25
H ₂ O	.	.	.	.	.	.	.	.	.	.	.	16.80

100.20

—*Zeit. f. Kryst.*, xviii., 668, 1891.OFFRETITE. *Ferd. Gonnard* (K,Ca)Al₂Si₈O₁₁ + 7Aq. Hexagonal.

In the basalt of Mt. Simiouse near Monbrison there is found, with much christianite (phillipsite) and a little chabazite, a very small amount of an apparently new zeolite, which the discoverer has named in honor of Prof. Offret of Lyons.

The mineral occurs as very small isolated crystals, $\frac{1}{4}$ m.m. to $\frac{1}{3}$ m.m. by 1 m.m., which appear to be simple hexagonal prisms and complex barrel-shaped forms. Cleavage, perpendicular to the base; G = 2.13; lustre, vitreous; colorless and transparent; polarizes light feebly. Before the blowpipe, whitens and fuses quietly to a white enamel. In tube yields water. In S.Ph. slowly decomposed leaving the SiO₂ skeleton. With soda fuses to a pale brown glass slightly greenish on fracture. Very slightly attacked by either hot or cold acids.

Analysis upon 0.5442 grammes showed:

SiO ₂	.	.	.	.	.	.	.	.	.	.	.	52.47
Al ₂ O ₃	.	.	.	.	.	.	.	.	.	.	.	19.06
CaO	.	.	.	.	.	.	.	.	.	.	.	2.43
K ₂ O	.	.	.	.	.	.	.	.	.	.	.	7.72
H ₂ O	.	.	.	.	.	.	.	.	.	.	.	18.90

100.58

—*Bull. Soc. Franc. Min.*, xiv., 58-60, Feb., 1891.OLIGOCLASE. *Pericline* of Pfitschthal.

As a result of an elaborate optical study of the pericline of Pfitschthal, Tyrol, L. Münzing concludes:

That the original mineral was an oligoclase, rich in soda, very porous and twinned as pericline is. That albite was deposited in the pores, partially filling them, but not completely, as is shown by the porous interior

of broken crystals. That as in similar deposits in orthoclase, the albite deposits were oriented, or arranged parallel to the structure of the oligoclase, retaining the twinned structure of pericline.

Chemical analysis: upon the mixture, which is practically inseparable by gravity liquids:

SiO ₂, .	.	.	.	.	.	.	.	.	.	.	64.21
Al ₂ O ₃, .	.	.	.	.	.	.	.	.	.	.	22.33
CaO, .	.	.	.	.	.	.	.	.	.	.	3.02
Na ₂ O, .	.	.	.	.	.	.	.	.	.	.	10.21
K ₂ O, .	.	.	.	.	.	.	.	.	.	.	0.45
											<hr/> 100.22

The pericline of Pfischthal must therefore be struck from the list of albites, but the periclinal of Zillerthal, Grossarl, Salzburg, St. Gothard, and Viesch are typical albites.—*Neues Jahrb. of Min.* 1891, ii., 1-11.

OPAL.

In large deposits, partly semi-opal, partly precious opal, at Vörösvágas (Hungary?).—*Zeit. f. Kryst.*, xix., 202, 1891.

PLESSITE.

In the Welland meteorite the so-called plessite was observed to consist of thin alternating lamellæ resembling in their physical properties kamacite and taenite. Carefully separated and analyzed the results were as follows: (For comparison the analyses of kamacite and taenite are also given.)

Kamacite.		Plessite.		Taenite.
		Kamacite-like bands.	Taenite-like bands.	
Fe, .	93.09	92.81	72.98	74.78
Ni, .	6.69	6.97	25.87	24.32
Co, .	.25	.19	.83	.33
C, .	.02	.19	.91	.50
<hr/> 100.05		<hr/> 100.16	<hr/> 100.59	<hr/> 99.93

This would seem to indicate that plessite is only a mixture of taenite and kamacite.—J. M. Davidson in *Amer. Journ. Sci.*, xlii., 64-66, July, 1891.

PLUMBOFERRITE. *L. J. Igelström. 2Fe₃O₄ + PbFe₂O₄. Isometric.*

Found at Jakobsberg, Sweden, in veins in the granular limestone and also associated with the jacobsite of the same locality; in this case likely to be mistaken for common granular or lamellar Swedish hematite, but separable by the magnet into the two minerals.

It has not yet been found in detached, well-formed crystals, but in the veins it occurs as lamellar masses, with evident cleavage resembling the Swedish galena, but not quite so clear. It frequently contains fine threads of native copper, which it is thought by the author accounts for the statement of the older books, that native copper occurs with mag-

netite in this locality. $H. = 5$; lustre, bright metallic; color, brighter than jacobsite; streak and powder, bright red; non-magnetic when pure; soluble in HCl without evolution of Cl.

It stands near franklinite and jacobsite, lead oxide taking the place of the zinc oxide of the one and of the manganous oxide of the other. Analysis shows:

	As found.	Recalculated after deduct- ing CaCO_3
Fe_2O_3 ,	55.58	60.38
FeO ,	9.83	10.68
MnO ,	2.00	2.20
PbO ,	21.29	23.12
CO_2 ,	3.50	—
CaO ,	6.00	1.67
MgO ,	1.80	1.95
	<hr/> 100.00	<hr/> 100.00

Corresponding to $2\text{Fe}_3\text{O}_4 + \text{PbFe}_2\text{O}_4$.—*Zeit. f. Kryst.*, xix., 167-170, 1891.

POLLUCITE.

Upon analyses of very pure pollucite from Hebron, Maine, and a recalculation of the original analysis by Plattner and of a later one by Pisani, as well as from the fact that the generally accepted formula of Rammelsberg is based upon "a single analysis where an important constituent was determined by difference;" Mr. H. L. Wells concludes that the formula for the Maine and the Elba material is $\text{H}_2\text{R}'_4\text{Al}_4(\text{SiO}_3)_9$ or 9SiO_2 , $2\text{Al}_2\text{O}_3$, $2\text{R}'_2\text{O}$, H_2O . In the Maine mineral R' is $\frac{1}{18}\text{Cs}$. $\frac{5}{18}\text{K}$ $\frac{7}{18}\text{Na}$.—*Amer. Journ. Sci.*, xli., 213-220, March, 1891.

POLYCRASE of North Carolina.

Supplementary note by Hidden and Mackintosh recording new crystalline faces and presence of Scandium, etc.—*Amer. Journ. Sci.*, xli., 423-425, May, 1891.

PROTONONTONITE *Knop*.

A dark leek-green mineral which, intermixed with calcite, forms a whitish green, resinous somewhat columnar mass quite filling the nut-sized cavities in the Limburgite of Sasbach.

SiO_2 ,	48.52
Al_2O_3 ,	5.94
FeO ,	6.00
MgO ,	24.72
MnO ,	0.59
CaO ,	2.79
H_2O ,	10.70
	<hr/> 99.26

—*Zeit. f. Kryst.*, xviii., 668, 1891.

PYRITE.

Study of crystals from Porkura, Hungary. A. Schmidt.—*Zeit f. Kryst.*, xix., 58-62, 1891.

QUARTZ.

Crystal faces of quartz of Malenco, Italy.—*Zeit. f. Kryst.*, xix., 205-206, 1891.

New faces on Zillerthal amethyst.—Cathrein in *Neues Jahrbuch*, 1891, i., 217.

REALGAR.

Realgar, orpiment and the accompanying minerals from Casa Testi, Mt. Amiata, Province of Grosseto.—G. Grattarola, *Giornale di Mineralogia*, i., 278-298, 1890.

RECTORITE. *Brackett and Williams*, Al_2O_3 , $2SiO_2$, $H_2O + Aq$. *Monoclinic*. (?)

Occurs in flexible non-elastic leaves or plates resembling mountain leather. H., less than talc; feel, soapy; color, white when pure, reddish-brown when impure. Infusible, becomes brittle on heating. Mean of two analyses shows:

SiO_2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	52.80
Al_2O_3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	36.05
Fe_2O_3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.25
CaO	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.45
MgO	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.51
K_2O	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.26
Na_2O	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.83
Ignition	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7.74
																		100.89
Water at 110° C.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8.57

Found in deposits in sandstone at Blue Mountain mining district, Marble township, Garland Co., Ark. Named after Hon. E. W. Rector, of Hot Springs, Ark.—*Amer. Journ. Sci.*, xlii., 16-21, July, 1891.

SERPENTINE.

M. Georges Friedel has examined one of the two forms of serpentine from Tilly Foster described by Prof. J. D. Dana as pseudomorphic, after an unknown mineral.* It consisted of a pale green mass, with very distinct cubic cleavage and in places equally distinct octahedral cleavage. The cleavage surfaces are brilliant and pearly. Even with the naked eye it is seen that at each cleavage plane very fine lamellæ of transparent material are intercalated, which give the brilliant lustre. These lamellæ possess micaceous cleavage and also two cleavages at right angles to each other, one more easy than the other, so that the general form is a rectangular plate. Under polarized light, all around the sides

* *Am. Journ. Sci.*, S. 3, viii., 375 and 451.

of the rectangle appears a band of doubly-refracting fibres exactly perpendicular to the faces of the cube. In the centre are noticed fibres parallel to these and other fibres at angles of 45° to the first. With a section parallel to the face of the octahedron six directions of fibres are shown, three parallel to the edges of an octahedron and three the projections of which are at right angles to these edges.

The mineral is evidently composed of two substances—the crystalline substance, which forms a network of rhombohedral lamellæ, crossing each other at the angles of the cube and the octahedron, and an amorphous substance, which fills all crevices and is itself penetrated by the same fine fibres which are components of the lamellæ.

An analysis of the carefully separated fibres yielded :

SiO ₂	.	.	.	.	.	.	.	.	.	.	41.98
MgO	.	.	.	.	.	.	.	.	.	.	41.38
FeO	.	.	.	.	.	.	.	.	.	.	2.87
H ₂ O	.	.	.	.	.	.	.	.	.	.	13.78
											100.01

This is practically identical with the composition of the entire mass and corresponds to a serpentine of 2SiO_2 , 3MgO , $2\text{H}_2\text{O}$. The two substances are therefore identical chemically, and since their specific gravity, solubility and blowpipe characters agree with serpentine, and as their optical characteristics concord with Des Cloizeaux's study of the varieties marmolite, antigorite, metaxite, chrysotile, bastite and thermophyllite, it seems that the material of Brewster's should be considered as *crystallized serpentine in pseudo-cubic groupings*, the interstices of the lamellæ having been filled up during crystallization by amorphous serpentine.—*Bull. Soc. Franc. Min.*, xiv., 120–127, April, 1891.

STRONTIANITE.

Description of crystallization at Leogang, Salzburg, and bibliography.—*Zeit. f. Kryst.*, xix., 146–152, 1891.

SYCHNODYMITE *Laspeyres*. $(\text{Co}, \text{Cu}, \text{Fe}, \text{Ni})_4\text{S}_8$. *Isometric*.

In the druses of an irregular, fragile, skeleton-like mass of intermixed quartz, siderite, tetrahedra and pyrite are found crystals of a metallic, dark steel-gray mineral, which, upon examination, prove to be the cobalt compound corresponding to polydymite, whence the name, from *συχνός* = *πολὺς*.

The crystals are rarely over 1 mm. in size, and are frequently the simple octahedron, but show sometimes the cube and the trisoctahedra 3O_3 and 2O_2 .

Material selected with extreme care yielded sp. gr. 4.758 and :

S	.	.	.	.	.	.	.	.	.	40.645	40.328
Cu	.	.	.	.	.	.	.	.	.	18.984	17.233
Fe	.	.	.	.	.	.	.	.	.	0.927	0.821
Co	.	.	.	.	.	.	.	.	.	35.786	35.635
Ni	.	.	.	.	.	.	.	.	.	3.658	5.744
											100.000
											99.761

—*Zeit. f. Kryst.*, xix., 17–21, 1891.

TALC *Agalite*.

The fibrous material from northern New York, with the composition of talc, is, from its optical properties, an altered enstatite.—*Neues Jahrb. f. Min.*, 1891, i., 376, Ref.

TAMARUGITE. *Schulze*. $\text{Na}_2\text{Al}_2(\text{SO}_4)_4 + 12\text{H}_2\text{O}$.

Occurs in massive forms, with radiated structure and cleavage across the fibres. Color, white; lustre, vitreous; H. = 2; G. = 2.03–2.04. Found abundantly at Cerros Pintado and Tarapaca, with pickeringite. Named after pampa of Tamaruga.

	Analysis shows.	Deducting NaCl and CaSO_4 .
SO_3 ,	45.66	45.37
Cl,	0.12	—
Al_2O_3 ,	14.48	14.48
Na_2O ,	9.04	8.94
CaO ,	0.20	—
CuO ,	trace	—
H_2O ,	30.86	30.73
	100.36	99.52

—*Neues. Jahrb. f. Min.*, ii., Refs. 21–22, 1891.

THOMSONITE.

In the amygdules of a feldspathic porphyry at Mettweiler, near St. Wendel, Germany.—*Zeit. f. Kryst.*, 171–173, 1891.

THORITE.

Orangeite of Landbo, Norway. Said by Hidden to belong to the uranothorite of Collier.—*Amer. Journ. Sci.*, xli., 440, May, 1891.

TITANITE, from Magnet Cove. Ark.

Analysis and crystalline form.—Genth and Penfield, *Amer. Journ. Sci.*, xli., 398, May, 1891.

TSCHIEFFKINITE.

As a result of analysis of a specimen of this mineral from Bedford Co., Va., and of a microscopic examination of thin sections of this specimen and of the previously analyzed specimen of R. C. Price, the conclusion is reached that tscheffkinite is a complex mixture of undetermined minerals.—*Amer. Journ. Sci.*, xlii., 36–38, July, 1891.

TURQUOIS.

Prof. Bogdanowitsch describes the turquois mines of Persia. The locality is Mt. Ali-Mirsa, north-west from the village of Maaden, near Nischapur. The mineral is usually in an iron-bearing, brecciated pitchstone belonging to the felsite porphyrys; rarely and only at great depths is it found in a typical breccia. It is found sometimes as enclosures in

limonite gangue and between breccia; in some cases it cements pieces of the stones. It is probable that the alumina phosphate solution penetrated from above.—*Zeit. f. Kryst.*, xviii., 631, 1891.

Old Indian workings have been rediscovered in the Burro Mts., southwest of Silver City, Grant Co., N. M., also about a mile from these in a test pit sunk in search for copper, the veins of turquoise having been mistaken for veins of copper-ore.—Chas H. Snow, *Amer. Journ. Sci.*, xli., 511, June, 1891.

VESUVIANITE.

Discussion of analyses and probable formula, $4(2\text{RO}.\text{SiO}_2) + 2\text{R}_2\text{O}_3.3\text{SiO}_2$.—Kenngott, *Neues Jahrbuch*, 1891, i., 200–207.

XENOTIME.

As an accessory element in rocks.—O. A. Derby, *Amer. Journ. Sci.*, xli., 308–311, April, 1891.

BOOK REVIEWS.

THE CHEMICAL ANALYSIS OF IRON. A Complete Account of All the Best Known Methods for the Analysis of Iron, Steel, Pig-Iron, Iron-Ore, Limestone, Slag, Clay, Sand, Coal, Coke, and Furnace and Producer Gases. By Andrew Alexander Blair, Graduate United States Naval Academy, 1866, etc. Second Edition. Philadelphia. J. B. Lippincott Company. 1891. 314 pp. \$4.00.

In a certain sense the publication of the first edition of this valuable work was a departure from the ordinary methods. Instead of preparing a book intended as a guide to students in laboratories of technical instruction, Mr. Blair undertook to supply concise information as to methods of analysis for the reference and guidance of students of more mature knowledge and experience. The results proved how well such work was appreciated in the rapid sale of the first edition, so that for the past year or more the numerous inquiries for copies at the shops of dealers in technical publications have been met with the discouraging reply, "out of print." One reason for this is reported to have been that our English cousins "know a good thing when they see it," and consequently an unexpected demand for the book sprang up in England soon after its appearance, which indicated that it had a wider field of usefulness than perhaps the author, or his publishers, had at first suspected.

The second edition is, therefore, assured of a hearty welcome. It contains only thirty-two pages more than the first, but the additions have been numerous, and give evidence of the most careful revision. A brief review of the new features may prove useful:

Under "Apparatus" we find a description of Mr. Maunsel White's mechanical device for pulverizing ores in an *agate* mortar, both mortar and pestle being rotated, and at the same time given a rocking motion (p. 13); also his device (p. 16) for taking samples of iron and steel, for the colorimetric carbon determination, etc., a combination of a drill with a balance, the movable pan receiving the drillings being poised above the balance beam and outside of the case.

Whitfield's convenient arrangement for hastening evaporation by the use of a blast passed through a heated platinum helix-tube (*Jour. Anal. and App. Chem.*, v., 181, 1891), is also described (p. 21).

In this division of the work we also find the suggestion as to the use of "Factor weights" (p. 37), a device which saves much labor and danger of errors. It consists simply in weighing out for analysis such an amount that the weight of the product obtained bears some simple ratio to the percentage of the constituent sought, *e.g.*, if one weighs out 2.7273 grammes of steel, every 0.0001 gramme of CO₂ obtained indicates 0.001 per cent. carbon, etc.

In at least one of our large iron-works, where numerous analyses are required daily, it has been found convenient to have in the laboratory a set of weights constructed on this basis for the different determinations required. Thus they have a carbon weight of 2.7273 grammes, a sulphur weight, etc.

Under "Reagents," Prof. Hart's invention of cursive bottles for the keeping of pure hydrofluoric acid for laboratory purposes receives mention (p. 39).

The usual method of making sulphur dioxide with copper turnings and sulphuric acid, omitted in the first edition, is given in this issue (p. 41). In many respects it has decided advantages over the method with charcoal.

The statement of the first edition that ammonium oxalate is soluble in three parts of water is repeated (p. 45). This is no doubt given on the authority of Gerhardt or Griffiths, quoted in Storer's *Dictionary of Solubilities*. One usually finds, however, that when the solution is made according to the directions of Fresenius (1 in 24), a solution saturated at ordinary temperatures is obtained. This seems to accord with the statements of most other authorities quoted by Storer as to its solubility. (1 in 20, Gmelin; in about 28 parts, Berzelius; in 22.2 parts, M. R. and P.; in 25 parts, Wittstein; in 24 parts, Abl.)

We note that the use of hydrodisodic phosphate as a reagent is ignored in both editions, that of "microcosmic salt" which has some advantages being substituted (p. 46).

The use of anhydrous copper sulphate *without pumice* is a new point in the second edition (p. 53), as is also the use of anhydrous cuprous chloride (*Ib.*). This form for those reagents has been suggested by the light obtained in the recent experiments preliminary to work on the International Standards. From the same source comes also the suggestion as to the use of potassium copper chloride (p. 54), instead of the corresponding ammonium salt, for dissolving manufactured irons, with a view to the determination of carbon.

Under "Analysis of Iron and Steel" we find added Morell's process for sulphur by the evolution method, involving passage of the gases through a cadmium solution (p. 62), and also Wood's modification of the same, combining the method with the iodine titration process (p. 71).

The color comparison methods for sulphur—that of Eggertz with metallic silver, and that of Weborgh with muslin disks impregnated with cadmium solution—are ignored, possibly because the author found them to be troublesome and inexact.

In the description of rapid methods for the determination of phosphorus by titration (Emmerton's method), we find inserted a description of Jones's reductor (p. 99). Woods's modification of Emmerton's method, in which the phospho-molybdate is weighed (p. 102), is also a new feature. The saving in time and manipulation by using chromic acid to insure complete oxidation, and a limited quantity of hydrofluoric acid to remove silica from the acid solution, are interesting and ingenious details in this method.

Strangely enough, however, Drown's modification of this volumetric process (*Trans. Inst. Min. Eng.*, xviii, 90), consisting in dissolving in nitric acid sufficiently dilute to render filtration easy, and effecting complete oxidation of the phosphorus by means of permanganate, seems to have escaped the author's notice.

In the gravimetric determination of manganese (Ford's method) is inserted Mr. Woods's suggestion of removal of much or all of the silica after effecting solution, by the addition of a few drops of hydrofluoric acid to the acid solution and boiling (p. 111).

To the Ford-Williams' method is added a description of the Uehling

burette (p. 116), a form of apparatus which easily recommends itself in other processes as well.

Deshay's method for manganese—oxidation to permanganic acid by nitric acid and lead peroxide, followed by titration with sodium arsenite (p. 118)—is also new.

In describing the determination of total carbon by direct combustion of the iron drillings in a current of oxygen, the author inserts a modest foot-note (p. 125), suggesting an original and effective mode of accomplishing the object desired. The wire-stand for Liebig bulbs (p. 136), and the mechanical stirring apparatus (p. 139), are also valuable aids in laboratory work devised by the author.

The point discovered by the American members of the International Steel Standard Committee, that acidulation of the copper chloride solution is of advantage when dissolving iron for a carbon determination, is noted (p. 140).

It suggests our present ignorance both as to the possible condition of carbon in manufactured irons, and as to the probable complexity of the reactions involved in this stage of the process. In this section (Determination of Carbon) various modifications of former methods are introduced, as the result of the experience of the members of the committee, such as the use of cuprous chloride and cuprous sulphate (both anhydrous) in the purifying train, instead of anhydrous copper-sulphate on pumice and copper turning, the use of compressed air, etc. (p. 121).

The presence of carbon compounds in copper-ammonium chloride is noted (p. 151).

The ingenious apparatus in use at the laboratory of the Bethlehem Iron Company for the addition gradually (and automatically) of the proper amount of nitric acid in dissolving samples of steel for the colorimetric determination of combined carbon, is described (p. 164), we believe for the first time.

The suggestion of Wood as to the omission of graduations at the lower part of the color-comparison tubes (p. 166), is novel and valuable.

A short paragraph has been added regarding the analyses of nickel steel (p. 180). It is recommended to weigh the nickel as Ni_2S (Rose's method). Classen's method—electrolysis of the *hot* solution of the double oxalate—we believe to be a better plan.

The methods of Stead and Carnot for the determination of aluminum in ferro-aluminum and aluminum steel (*vid.* QUARTERLY abstracts, xi., 273, and xii., 262; also xii., 61) are inserted (p. 185), though the account is unnecessarily mixed in with the determination of chromium as well, in a way tending to be a little misleading as to the object sought.

A new section (p. 195) is devoted to the determination of nitrogen in irons. The method described is that of A. Hallen as modified by Langley (distilling and determination as ammonia).

Another new section (p. 198) gives methods for the determination of iron in manufactured irons by the solution method and by the fusion method.

Under "Analysis of Iron-Ores," the use of Jones' reductor is described (p. 204). That apparatus, however, when constructed according to directions, is unnecessarily elaborate.

An arrangement is also described (pp. 205 and 206) for establishing a reservoir in conjunction with the burette for standard permanganate solution, so connected that the burette may easily be filled an indefinite number of times, or the burette may be emptied back into the reservoir, without exposing the standard solution to laboratory fumes or any other influences which might injuriously affect its strength.

As regards the use of potassium dichromate for the titration of iron, the description in either the old or the new edition is not altogether satisfactory. It is implied, if not stated, that reduction of the iron by metallic zinc can be used when titration with this reagent is contemplated, whereas the reaction of the dissolved zinc salt with the ferricyanide used in determining the end-reaction, practically constitutes a material objection to this method of working. The author also neglects to mention the most satisfactory method of reducing with stannous chloride; addition of a slight excess, and then adding *at once* 15 to 20 c.c. of a solution of mercuric chloride to destroy the excess of stannous salt. It has also escaped his notice, that this method of titration is applicable in the presence of titanous acid without appreciable error.

Another omission may be noted (p. 243): the separation and weighing of zinc as phosphate, in a manner analogous to that of manganese.

The remaining sections are essentially reproductions of the text of the first edition, with the exception that in the direction for the analysis of "Fire Sands," the important note is added (p. 273), that in the presence of much alumina, it is almost impossible to expel all the silica by the use of hydrofluoric acid in the ordinary manner.

No additional tables have been inserted in the new edition, but two of the most important ones have been carefully revised, viz., that of the atomic weights (Table I., p. 295) and that of the factors (Table II., p. 296).

The atomic weight table corresponds very nearly, though not exactly, with the recent list published by Prof. F. W. Clarke. The differences where they occur are practically unimportant, being usually only of two or three hundredths.

The table of factors has been changed to correspond with the revised list of atomic weights, and several additions have been made.

With the exception of a few verbal changes this sums up the numerous additions and improvements to be found in the second edition. The proof reading has been exceedingly thorough, the typographical errors being few and unimportant (p. 159, Karston for Karsten, for instance). The type, spacing, size of page, binding, etc., are pleasing and satisfactory. The work is sure to be eagerly sought by those whose work is connected with such matters, because it is useful and thorough.

E. WALLER.

APPLETON'S SCHOOL PHYSICS. By John D. Quackenbos, A.M., M.D., Columbia College, N. Y.; Alfred M. Mayer, Ph.D., Stevens Institute, Hoboken, N. J.; Francis E. Nipher, A.M., Washington University, St. Louis; Silas W. Holman, S.B., Mass. Institute of Technology, Boston; Francis B. Crocker, E.M., School of Mines, Columbia College. Cloth, 12mo., 544 pages. New York, Cincinnati and Chicago: American Book Company.

APPLETON'S SCHOOL PHYSICS is the latest attempt to condense into

one small volume the mass of facts with which the candidates for admission to our colleges must be familiar before entering upon more advanced work in natural philosophy. Unlike most of its predecessors, it is the joint work of several writers: Prof. A. M. Mayer, of Stevens, contributing the chapter on sound; Prof. Nipher, of Washington University, those on heat, light, frictional and voltaic electricity; Prof. S. W. Holman, that on mechanics. In addition, there is an excellent presentation of the modern applications of electricity by Prof. Crocker, of Columbia.

The form and arrangement of the book are much the same as those of the physics with which we are familiar, but the subject-matter has gained much by the omission of many utterly insignificant paragraphs, with their explanatory cuts, that were deemed necessary in other books simply because they had come down to us from the natural philosophies of sixty years ago. There is thus more space to devote to the modern applications of scientific research noticeable in every chapter.

The cuts are another departure from the venerable antiques of Ganot, from whom almost all our smaller books have borrowed freely. The result of these changes is to make a fresh, interesting text-book; concisely expressed and well-illustrated; displaying an honest attempt to throw off conventional forms of presenting the various branches of physics; and showing the student what the scientists are doing for the practical world *now*, instead of giving him an historical view of physics up to only 1850. Our only regret is that the authors did not go far enough in revolutionizing; they are still too hampered by the past. Under the able editorship of Prof. John D. Quackenbos, of Columbia, the work is the best in its particular sphere that has yet been produced.

G.

BULLETIN OF ALUMNI AND COLLEGE NEWS.

THE ALUMNI.

The Secretary writes: "Delay in returns, press of business, and an attack of chills and fever preclude my getting list of the Alumni in shape for the July issue."

THE COLLEGE.

No more interesting reading can be found for those interested in the development of the School of Mines than the recently-issued circular of information. The following facts are selected as embodying the more recent changes.

The system of instruction in the School of Mines includes:

I. *Undergraduate Courses*, occupying four years.

1. Mining Engineering.
2. Civil Engineering.
3. Metallurgy.
4. Geology and Palæontology.
5. Analytical and Applied Chemistry.
6. Architecture.

II. *Post-Graduate Courses*, full course of two years.

1. Electrical Engineering.
2. Sanitary Engineering.
3. Special.

UNDER THE UNIVERSITY FACULTY OF MINES:

Elective Courses.

1. For the Degree of Master of Arts.
2. For the Degree of Doctor of Philosophy.
3. Special Courses.

Seniors of the School of Arts are permitted certain electives.

For the convenience of candidates for admission to the first year of the School of Mines who reside at a distance from New York, arrangements have been made by which examinations will be held in June at the following cities:

Chicago, Ill., by E. G. Barratt, C.E.
Cincinnati, O., by C. B. Going, Ph.B.
Charleston, S. C., by P. E. Chazal, A.B., E.M.
Concord, N. H., by C. S. Knox, A.M.
Denver, Colo., by T. B. Stearns, E.M.
St. Louis, Mo., by W. B. Potter, A.M., E.M.
Salt Lake City, Utah, by R. H. Terhune, E.M.
Belmont, Cal., by W. T. Reid, A.M., Head Master of the Belmont School.

POST-GRADUATE COURSES.

Graduates of the School of Mines, and of other institutions, are admitted to post-graduate courses without examination, provided they have completed the studies which qualify them to pursue with advantage the courses which they desire to attend.

Persons who are not graduates may be admitted to the courses in electrical engineering and sanitary engineering, provided they pass the required examinations.

Graduates of colleges and technical schools, and other applicants of adequate attainments and mature age, who are not candidates for a degree, may be admitted to partial courses on giving satisfactory evidence that they are able to pursue with credit and advantage the special topics or studies to which they wish to devote themselves for one year.

Any student of the School of Law, the School of Political Science, the School of Philosophy, or the graduate department of the School of Mines, pursuing a full course, may attend permitted courses in any other school of the college without paying any further fee for tuition.

UNIVERSITY COURSES (under the direction of the University Faculty of Mines):

Any student who has taken his baccalaureate degree either in Columbia College or in some other college maintaining an equivalent curriculum (every such case of equivalence to be considered on its own merits), shall be entitled, with the approval of the president, to become a candidate for the degree of master of arts or doctor of philosophy.

Each student who declares himself a candidate for the degree of master of arts or doctor of philosophy, shall designate one principal subject and two subordinate subjects. In the Faculty of Mines the term "subject" shall be held to mean any one of the several subjects of instruction specified under groups A, B, C, and D. No candidate for a degree may select more than two of his subjects from any one group. The selection of subjects made by any candidate for a degree shall be approved by the dean on behalf of the faculty.

One year's study is required for the degree of master of arts; two years' study for the degree of doctor of philosophy.

The course of study shall, so far as possible, embrace instruction in the following groups of subjects:

A.—Mathematics.

B.—Mechanics,
Physics,
Chemistry.

C.—Biology,
Botany,
Zoology,
Palæontology,
Mineralogy,
Lithology,
Geology,
Astronomy,
Meteorology,
Physical Geography,
Geodesy,

Surveying.

D.—Engineering.

{ Civil,
Mechanical,
Electrical,
Sanitary,

Mining,
Metallurgy,
Architecture.

Students who are not candidates for a degree shall be permitted to pursue such courses, from among those offered by the Faculty of Mines, as they may be found qualified to enter upon and the faculty may approve. The qualifications of such students shall be determined by the professor in charge of the courses selected by them.

The following elective courses for the degrees of Master of Arts and Doctor of Philosophy, and special courses, are offered :

MATHEMATICS.

Advanced course in differential and integral calculus—2 hours a week.

Advanced course in solid geometry and higher plane curves—2 hours a week.

Modern higher algebra—1 hour a week.

General theory of functions—3 hours a week.

Abelian functions—1 hour a week.

Calculus of variations—2 hours a week for one term.

Differential equations (general)—2 hours a week for one term.

MECHANICS.

Higher mechanics—2 hours a week.

Determinants and modern co-ordinate geometry—2 hours a week.

The principle of conservation of energy and the various methods of its application to the study of physical phenomena.

PHYSICS.

Calorimetry.

Radiant heat.

Interference of light.

Polarized light.

Acoustic measurements.

Thermo-electricity.

Electrical induction.

Conversion of electrical energy into light and heat.

Each course will consist of 8 hours of laboratory work a week.

CHEMISTRY.

The history of chemical theory—1 hour a week.

The following courses will each consist of 8 hours laboratory practice per week :

Examination of new methods of analysis.

Spectroscopic analysis.

Analysis of the alkaloids.

Electrolytic analysis.

Study of special chemical reactions.
 The quantitative relations of the rare elements.
 Theoretical and industrial relations of iridium.
 Redetermination of certain atomic weights.
 The allotropic conditions of certain elements.
 Quantitative electrolytic analysis.
 Rapid methods of analysis in connection with metallurgical processes.
 Rapid methods of analysis in connection with certain processes in industrial chemistry.
 Special volumetric methods.
 Chemical examination of textile fibres.
 Chemical examination of dyes and dyed fibres.
 Investigation of fats and oils.
 Investigation of resins.
 Investigation of pigments.
 Investigations on organic acids.
 Investigations on alcohols.
 The chemical relations of substances in the manufacture of paper.
 Chemical relations of albumens and albumenoid substances.
 Organic magnesium compounds.
 On the action of organic acids on diatomic nitrils.
 Adipic acid and its formation from aromatic compounds.
 The action of thionyl chlorides on amides.
 Diatomic sulphones.
 Electrolysis of certain groups of organic acids.
 Technical sugar analysis.
 Special methods of assaying ores.
 Special methods of analyzing alloys.
 Special methods of analyzing and assaying furnace products.
 Quick methods of assaying ores, metals and furnace products.
 Ore testing for the proper selection of methods of treating alloys.
 The electrical treatment of ores and metals.

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Instruction in the theory of the reduction of photographic star plates, with practical application to the Rutherford star photographs.

Theoretical astronomy. Lectures on theory of planetary motions—1 hour a week for two years; and computations of comet orbits, etc.

BIOLOGY AND MICROSCOPY.

The fresh water algae and lower fungi—2 hours a week.

Protozoa and their sanitary relations—2 hours a week.

Micro-chemistry—2 hours a week.

Biological analysis of water and air—4 hours a week.

BOTANY.

Vegetable anatomy. Laboratory instruction in the preparation and examination of cells and tissues—2 hours a week.

Cryptogamic botany. Lectures, herbarium and laboratory instruction in the structure and classification of the ferns, mosses, lichens, higher fungi, and marine algæ—2 hours a week.

Morphology of the flowering plants. Instruction by text-book, models, diagrams and herbarium—1 hour a week.

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ZOOLOGY.

Anatomy. Laboratory work 4 hours a week.

Special anatomical work—not less than 4 hours a week.

Systematic study of some group of animals—not less than four hours a week.

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Higher studies in blow-piping—2 hours a week during one term.

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Advanced studies in combustion, calorimetry, and the behavior of slags—2 hours a week during the year.

GEOLOGY.

Higher geology—3 hours a week.

ENGINEERING.

Hydro-dynamics. General laws of motion of liquids and gases, with and without friction; mutual impulse of fluids and solids; work performed by various fluids as sources of power and laws of efficiency—2 hours a week.

Thermo-dynamics. Dynamical theory of heat; principles of thermo-dynamics applied to heat engines and various engineering problems—2 hours a week.

Dynamics of engineering. Laws of dynamics applied to engineering—2 hours a week.

Sanitary science. Water supply, sewerage, drainage, disposal of sewage, ventilation, heating—2 hours a week.

Rivers, harbors and breakwaters. Physical characteristics of rivers, estuaries and harbor bars; methods of improvements; location and construction of breakwaters and other marine works—2 hours a week.

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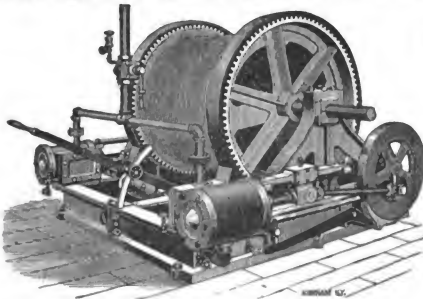


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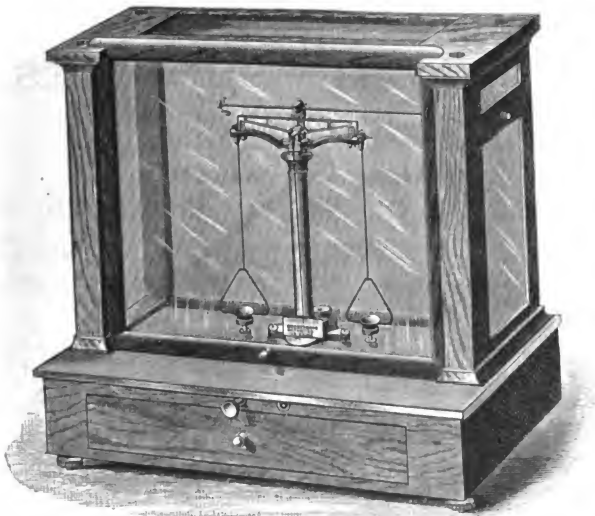
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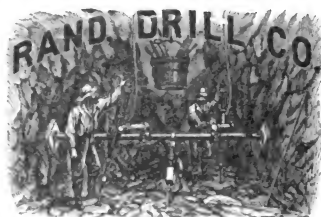
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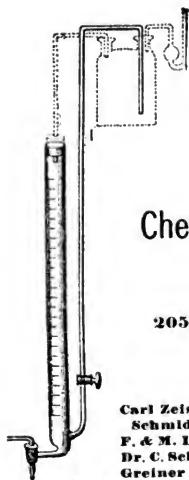
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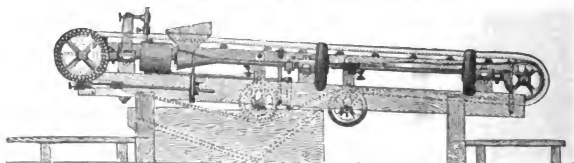
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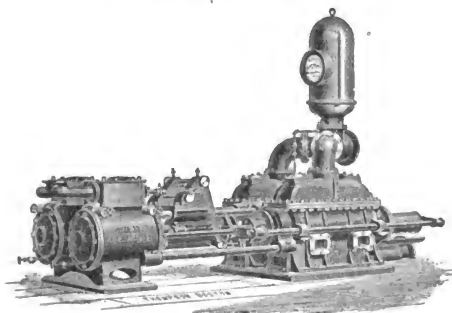
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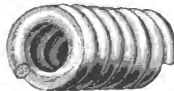
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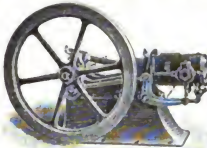


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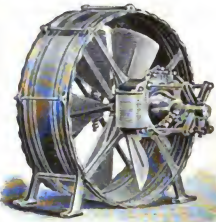
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No. 1.

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A

JOURNAL OF APPLIED SCIENCE.

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COLUMBIA COLLEGE.

NEW YORK CITY.

1890.

SCHOOL OF MINES QUARTERLY.

VOL. XI., 1889-90.

Subscription price two dollars per annum, or fifty cents per number.

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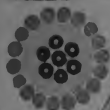
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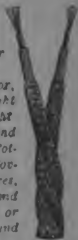
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